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SCIENCE: LEADING AND MISLEADING

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BY

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THIS BOOK I DEDICATE
TO MEN OF WIT AND UNDERSTANDING,
HOPING THAT THE INDIVIDUAL RESPONSES
MAY SWELL INTO
THE GREAT VOICE OF THE PUBLIC.

PREFACE

ALLOWING the eye to wander over the whole domain of science, one cannot but feel admiration for man. Here is this little fellow, cast naked upon a planet inhabitable only with difficulty, sailing in space he knows not whither, can vaguely guess why ; physically so meagrely endowed that he must envy the elephant his strength, the wolf his digestion, the frog his jumping powers ; and yet gifted with a superior intelligence and behoven to direct his eyes at every turn towards a certain signal—that of truth,—which, when he can discern it, answers unerringly "Yes" or "No," and by this alone suffices to lead him upwards.

Upwards indeed he has striven ; in ignorance, mental blindness ; by struggle, by ruthless violence at times ; through war and rapine, wholesale murder ; gradually discovering the world in half-fearful, half-heroic search, led or driven in dauntless ventures ; clothing himself, establishing himself in communities, providing reserves of food and implements ; finding himself at times seized and borne on high by strange currents of thought and emotion ; feeling the strong bonds of personal affections ; at length widening his outlook and his powers and

his sympathies, and reaching out and aloft to aspirations of greater living and to new vistas of entrancing thought. Marvelling and marvellous man !

The stars have guided him, and the star of his reasoning mind is that which in our present state of knowledge we call science.

Science is great. Discoveries in science are wonder voyages of the soul. But those who wield authority in science have not always been fair to their fellow-man ; they have sometimes deceived him, possibly because themselves deceived ; but they have also fallen to the worship of inferior divinities,—religious fanaticism or political prejudices ; conventional falsities ; hypocrisies, humbugs ; even the lure of social titles and personal distinctions, and other perversions which, though not without a plausible appearance, have wrought signal injustice and introduced grotesque inversions of values.

This is the theme of the present book, but in writing it I have not cared to speak in vague discontent.

It is usual to take for granted that, no matter what has been done in the past, our social system has become wellnigh perfect, our Universities great and liberal centres of illumination, our associations for the advancement of good things—including science—all wise and helpful institutions ; candidly, deliberately but sadly, I hold quite other views :

for I think that we are between two phases of development, and in that transition we have lost the surety of ignorance that often gave force to the doctrines of old, and we have only in a tentative way reached at the fruits of the new dispensation ; losing the old faiths we are deficient in moral courage, and we cover our deficiencies by pretence or simply by that never-failing and extensible garment of our hypocrisy ; in the world of thought in especial we live in a mist of falsity so all-prevailing that we have come to regard it as our normal atmosphere.

In this scene I see the figure of Science blurred and distorted, but I do not now affect the pose of an inspired Perseus rescuing from the claws of a monster the unsullied maiden, Wisdom ; I am content to take the rôle of the honest char who, with scrubbing-brush and soap, works at what she knows, strenuously removing the rubbish, and catching fleeting vision of the beauty that emerges from the midst of her toil ; for all that is done in the service of science wins surely a meed of grace.

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CHAPTER ONE

SCIENCE: LEADING AND MISLEADING

A REFLECTION that must often occur to those who cast their eyes on our scheme of civilization is that of the sense of "newness." So many of the great principles that we think important, or perhaps rather the practical corollaries which have flowed from them, from engines of great motive power to wireless telegraphy, seem so recent in their origin, especially in view of the many foolish notions which we have discarded, that one might think that the voyage of the world has scarcely begun.

On the other hand, when we contemplate the work done in the domain of science, to say nothing of art and literature, by the Greeks during the brief period of the efflorescence of Athens, we find that there is hardly a notion or a theory which now interests us which may not be found, at least in germ, amid the speculations of these ancient thinkers.

It would be well, indeed, if we had received from the pioneers nothing but the first suggestions of true science, and the main indications of the principles of development; but it has so happened in the course of our history that for centuries the

intellectual world has in great part forgotten, or misunderstood, what was of the highest importance in the Grecian systems, and has retained for its own edification and for the building up of its doctrines, the parts that were false or obscure in the teachings, for instance, of Plato and of Aristotle.

I am not here talking in a mood entirely archæological, for many of these false teachings persist in our own time, and especially in those matters of psychology and of ethics on which all the results of our positive science should impinge. The great German mathematician, Jacobi, began a lecture in Berlin in 1866 in these remarkable words:

"There was once a thousand years of Night."

The thousand years was comprised in the period between that of Greek decadence and the Renaissance from which our modern world may be said to date. That thousand years of night has left its shadows thick upon us, to a far greater degree than we are accustomed to believe, both in our modes of thought, our attitude towards science, our estimation of values and standards, and our respect for mere authority, not necessarily derived even from reputation in science itself.

Before entering upon a discussion of this subject, however, I beg to be allowed to dwell for a moment upon the thoughts and achievements of some of the great Greek philosophers, for even when we

smile in our superior wisdom at certain suggestions and theories that seem to tell of the infancy of the world, we are compelled to bow in respect before them in regard to one great quality which is indeed the very soul of science—they sought truth for itself. They found a sufficient stimulus for their efforts in the perpetual wonder of the unfolding of the world before their mental vision, and in the discovery of something new in science they reaped the reward of years of toil, or misapprehension, possibly of persecution at the hands of their fellow-citizens.

It is delightful to linger with them awhile, losing ourselves in their thoughts, their wanderings and strivings ; enjoying, possibly, our own superiority, yet sometimes feeling ourselves struck in sheer amazement and admiration at a deep stroke of intellect, the gleams of intuition, of divination by which they arrived at ideas, more and more interesting to us in proportion as our modern researches reveal the character of matter and the constitution of the world.

The title of the "Father of Science" has been accorded to Thales who was born 620 before Christ and who lived to the age of seventy-seven. Thales, like most of the famous Greek philosophers, was so well off in the world's goods as to be able to devote himself unrestrictedly to contemplation and research. He travelled far and wide, as the world

was known in those days, in search of enlightenment and he brought his science to such a point that he was able to predict eclipses; and he was also credited with being the first of the Greeks who offered a rigorous demonstration of the fact that in all equal-sided triangles the angles at the base are also equal.

He taught the Ionian mariners to navigate by observation of the Little Bear. On the other hand, some of his theories appear to us as but insecure bases upon which to build a system of philosophy. He attached especial importance to water, and he regarded the earth as condensed water and the air as rarefied water. He placed the earth in the centre of the world and, although he regarded the universe as spherical, he seems to have been content with a flat earth.

We must not too hastily condemn these ideas as mere crudities for we should always remember that most of our knowledge in regard to the teachings of the ancients has filtered through the minds of others who have been often little apt to understand them, and it is probable that if we could hear Thales himself discourse on these subjects, we would find that his mind was extraordinarily reasonable, and that the proper term to apply even to the suggestions which appear to us ridiculous is that, in those days of beginnings, they were elementary rather than erroneous. They imply that Thales

was thinking out the whole material system in terms of physics and chemistry, and that in regard to the physical world and to the mind of man he had the clear intimation of laws and harmonies which give meaning to all that we, however imperfectly, observe.

Thales in his heyday encountered the kind of criticism of science which is prevalent in our own time, and though he answered the questionings more triumphantly than is common with us, yet the problem brings us face to face with the search often begun, never terminated, for standards of value.

Even the servant of Thales mocked at him. "Here is a man," he said, "with his nose in the air and his eyes fixed on the stars, who falls into a ditch."

It is true that Thales might reply, if, like Dean Swift, he argued with his servant—"Yes, but by gazing on the stars and interpreting them, I can predict eclipses; or, if you still question 'What good is that?' I can teach those practical men, the Ionian merchants, how to steer their ships."

This answer might still seem unconvincing to the servant because, though it implied certain advantage to the community, it still left Thales himself in the ditch. Here we come to the old question of egoism and altruism, in which each one, even in our time, gives the highest laudation to the

altruism—of others, but usually for his own guidance anchors on the other well-tried principle.

These questions open out speculations of a much larger scope, as to whether the world and human life have any great value to us, or any profound significance as far as our existence as humans is concerned ; and, like Thales, though without being able to give more certain evidence, I merely assume that our human destiny is not to be measured even by the acts of physical enjoyment, to say nothing of those high standards which prevail nowadays in which the drones, the *amuseurs* or the fribbles and wastrels, are held up to admiration to the neglect of high intellectual endeavour.

Another criticism of Thales was that a man of his intellectual activity should make better use of his talents ; he should apply them to what are called "practical purposes." This of course was a shrewd thrust ; it implied greater intelligence than that exhibited by one of our own hereditary legislators, who disparaged science altogether in his demand for "useful men."

Thales felt the point touching him keenly, for it is perfectly reasonable that a philosopher should continue to demand, "What is the real value of his work ?", if only to give him strength to put aside the solicitations of pleasure and social intercourse, or the sterner joys of political ambition, or soldierly domination.

Thales answered by a great practical parable; he went boldly into the olive market and bought up all the olives in Crete, and by this mercantile operation produced a scarcity of that delectable fruit in Greece, and a consequent rise in price.

This was probably one of the earliest "corners" on record.

Having arrived so far, however, Thales took a step which may be diversely appreciated. Most people will think that he showed himself immeasurably inferior to the great Chicago "kings" who hold their victims in their claws until they writhe in all their fibres, and squeal and disgorge to the extent of their capacity, and who, standing on the pedestal of such great achievements, become hailed in the Republic of the Free as the most brilliant paragons of human life.

Was it sheer weakness on the part of Thales or was it in response to a motive that some will regard as superior? How can we tell? The fact is that Thales "let up" on his corner and released the olives without drawing a profit. He had at any rate shown to his friends that he was able to "make a pile" and he had the supreme satisfaction of convincing himself that such pursuits were poor compared to those on which he had set his mind. This noble spirit of Thales prevailed in Greece throughout the period of its bloom, and it is that rather than the actual concrete achievement that

makes it so consoling to us to turn our eyes again to these great examples.

Pythagoras was truly a wonderful being. His influence is felt with us to-day if only by reason of certain words and phrases with which he has endowed our language. Pythagoras believed that the earth was round, and that the stars were incandescent globes which moved around it. In their movement they produced a harmony—"music of the spheres"—which is not heard by us because our senses are too gross to perceive this music. The phrase has become immortal. What of the meaning of it? We have been accustomed to smile at that as a feat of poetic imagination, but the latest theory of the atom would have us believe that the electrons circulate round a centre; and, in the first expression at least of that theory, the undulations of light were attributed to these movements, and the periodicity of these undulations was put forward as a support for the theory. Bohr has certainly modified this conception, but the notion is there all the same of undulations of the ether being produced by these regular movements of the electrons.

But we also believe that the ether pervades all space, at any rate the space through which come the impressions of light. The planets therefore are also in their orbits producing waves of ether and if we do not directly perceive them it is because our senses are limited to a very small portion of

the scale in which the undulations range from beyond the vast electrical waves used in long-distance wireless to those of inconceivable minuteness recently demonstrated by Professor Millikan which impinge upon our earth from extra-terrestrial sources.

Here is a certain intuition of the Greeks which make us leap at the wonder.

Pythagoras was also one of those minds, unfortunately too rare, who saw no antagonism between science rigorously conceived and the delight of the arts—particularly of music. This spirit of his was prevalent among the Greeks and is to be found again in the great thinkers and artists of the Renaissance, in Leonardo da Vinci, for instance, and in Michael Angelo.

In the midst of his high speculations, Pythagoras recognized the necessity for rigour in argument, and he insisted, as did Galileo subsequently, that in order to found a true science we must begin at the deepest base and build successively step by step, testing each fresh step by the severest criticisms that we can command. To him we owe the convincing demonstration of the truth of the proposition, now called the Pythagorean proposition, that in a right-angled triangle the square on the side opposite to the right-angle is equal to the sum of the squares on the other two sides. The truth of this proposition had been guessed long before Pythagoras

and there is, I have been told, an inscription on one of the Pyramids which shows that the Egyptians of that day had arrived at a demonstration, which differed, however, from that of Pythagoras.

Pythagoras is also the father of the theory of numbers, even though his contributions were somewhat elementary. It may be recalled here that Gauss, the great German mathematician, a man of wide culture, described mathematics as the "Queen of the Sciences," and the theory of numbers as the "Queen of Mathematics."

Pythagoras attached to numbers an importance which almost escapes our apprehension.[1] He

[1] The Pythagorean Doctrine of Numbers had a great vogue right through the Dark Ages, and it was by virtue of the subtle reasonings derived therefrom that the most brilliant of the Schoolmen were able to ascertain exactly how many angels could stand on the point of a needle. The kind of needle was never specified; the number, *666*, remained a sort of universal constant. Raymond Lulli—an extraordinary genius, if ever there was one—also made great play with numbers. The appeal to numbers in themselves exercises a fascination over many minds; Cheiro, the palmist, once told me that he relied on combinations of numbers to achieve what otherwise I would have imputed to his discerning common-sense and his knowledge of human nature.

Then in quite another mood I find a remark of Sir Oliver Lodge in his Presidential Address to the British Association in 1913, where he said that if during the investigation of phenomena a whole number appears, special significance should be attached to it. He cites the atomic weights and also the fact observed by Clerk Maxwell in his researches on electro-magnetism—that the proportion of the figures representing the velocity of light to those obtained by taking

thought six to be the perfect number because it was equal to the sum of its factors, three, two, one.[1] He also had a quite particular respect for the number seven which, though offering as a prime number no such amenities of that kind, yet seems to gain strength from a certain uncompromising austerity. The series seven enters into all sorts

the inverse square root of the product of the electro-static and electro-magnetic units was always unity. This remark led Clerk Maxwell to speculations that light and radiant electricity were similar phenomena differing mainly in the length of the waves involved. These considerations eventually produced the suggestions of Helmholtz on which his pupil Hertz worked, and which laid the foundation of our system of wireless telegraphy.

I recognize the full value of Sir Oliver Lodge's remark the more readily in that I propose later to deliver a frontal attack upon him, not on the ground of such interesting speculations, but on the theories he has given forth in his own special subject.

[1] One reason for the preference given to the number six in ancient systems has been offered by Professor Hoppe, of Hamburg, who remarks that if six equilateral triangles be placed in a circle, each with an apex on the centre and the other two angular points on the circumference, these six triangles would complete the circuit.

He says that this property was known to the Babylonians, and he points to the fact that, whereas in Egypt and in Greece the wheels of ancient chariots had four spokes, the Babylonian wheel had six.

Pythagoras did not, however, proceed from this point of view for, even though he may have noticed such a fact as affording some confirmation of the value of six, his regard for the number itself was of too pure a quality to be dependent upon these applications. This respect for numbers, and for theoretic considerations generally, was long after revived by Kummer, who wanted his mathematics kept pure and unsullied from applications.

of matters, whether from the number of our days, or of the numbers supposed of the planets.

Another of the notions of Pythagoras was that the planets moved in circles at a uniform velocity. We know, since Kepler, that this is not the case, and so we are better able to see the weak point of the old Greek's reasoning. He said that the circle was the most perfect figure, and that with respect to rapidity of movement it would be undignified even for a man sometimes to be precipitate and sometimes to be retarded. We smile, but I venture to say that if once the hint be given, a keen observer will find this mode of reasoning of Pythagoras prevalent amongst us still in a thousand forms, and particularly in the assumptions that we make in our philosophical and religious systems.

Moreover the error proceeds from the misapplication of the true principle; all through the development of science thinkers have been guided by the search of law, of harmony, and ultimately, indeed, by a sense of beauty. But we err in striving to restrict Nature at every turn within the compass of our own weak imagining. The law was there, the beauty was there, even the grandeur of simplicity, but Kepler's laws and Newton's interpretation have enabled us to discover these principles at a higher level than was possible to Pythagoras.

Before leaving him, I would touch for a moment again on his principle of numbers. The aphorism

of Gauss, for example, arose from the reflection that, when we understand the relations of phenomena, we express them as far as we can mathematically. Our formula contains the meaning, as apart from the graphic forms in which it is presented, and the formula is more general than the particular case which drew it forth. But all our formulæ depend ultimately on the expression of numerical relations, and so the theory of numbers is the matrix from which our mathematics proceeds.

That, I feel convinced, is the explanation of some of the extraordinary sayings of Pythagoras with regard to numbers, and the more I think of the total value of his work—especially in view of the elementary knowledge which prevailed in his day—the more I stand in wondering admiration of so high an intellect. His influence was felt long after amongst the Greeks; Plato was in many respects his disciple, and his teachings influenced and guided Descartes in the establishment of his system of philosophy.

It is extraordinarily interesting to trace out the successive developments of Grecian thought, but our present space permits only the briefest references.

Anaximander, who was born at Miletus in the year 610 B.C., and who lived to 547 B.C., had a clear notion of the sphericity of the earth. He was also

distinguished for inventing a simple apparatus for calculation. The question may be asked here how the notion of the sphericity of the earth became suggested to the Greeks and how, subsequently, that true idea was lost. For one thing in the clear skies of the South, the moon, when at its full, looks like a globe in the sky ; and if, as once I beheld in the Southern Ocean, the surface is perfectly smooth, without a ripple, the notion is irresistible that one is floating on the surface of an immense sphere.

To complete their notion of the solar system, the Greeks lacked one conception with which later science has endowed us, namely, that the sun is the figure around which the system moves, though on that score I will refer subsequently to a deep remark of Henri Poincaré who put the matter in the true light. The loss of this clear conception was due to religious teaching which, when false, as it nearly always is, proves to be the most perverting influence the human mind has known.

It was Anaxagoras, born at Clazomenæ, 500–428 B.C., who developed to a high degree the notions of Anaximander. He, too, believed in the sphericity of the earth, and he accounted for the stars and the moon on a theory which, afterwards taken up by Kant and subsequently expounded in scientific form by Laplace, is still accepted under the title of the Nebular hypothesis.

Anaxagoras was one of the first to offer a clear and definite distinction between matter and spirit, and in the development of these ideas his conceptions have quite a modern appearance. The principle which recognizes that *Nous* or Intelligence has devised the world has given us the vision of a system not to be altered by occasional interventions, but which proceeds inevitably in a continual enchainment of phenomena governed by certain laws which it is the chief duty of science to ascertain.

He had still another notion which, in view of our latest theories of the constitution of matter, has an air of divination. He accepted the Atomic theory, but he did not regard the atoms as the ultimate basis. The atoms were finite in number but, underlying the atoms and helping to build them, were the homœomeries—infinitesimal elements beyond which the mind could not penetrate.

Viewing the work of Anaxagoras and the system he evolved, one is induced to regard him as one of the highest intellects of all time. In spite of that, however, or, if we search a little more deeply into the matter, because of that, he was looked upon with disfavour by the politicians of the day and the conservators of the orthodox religions. He was accused of corrupting the minds of the people by false doctrines, but lest such a charge should appear somewhat uncertain, there was added to it that of lack of patriotism. He was believed to favour the

Persian system and, by reason of the prejudice worked up against him, he was condemned to death, and was only saved from that fate by the active intervention of Pericles who advised him to go into exile to Lampsacus. There Anaxagoras finished his days in poverty and neglect.

Pericles, too busy with other affairs, had forgotten his friend but during his last days he came to visit the dying man, and regretted to find him ending his life in such miserable conditions. Anaxagoras received his visit with gratitude, but could not forbear to utter one of those aphoristic sayings of the Greeks, whose truth has given them such vitality: Who wants a lamp keeps it in oil.

Before the time of Anaxagoras we meet with Heraclitus (576–480), whose teachings undoubtedly influenced the great thinker of whom we have spoken and also Plato and the school of the Stoics. In Heraclitus we find the early apprehension of the principle of evolution. He saw everywhere, as an essential of the life of the world, a continual movement and change. "One cannot bathe twice in the same stream."

He saw the stuff of things subsisting always but ever changed into new forms; that evolution was governed by a certain intelligent principle,—*Dike*, or, as he sometimes called it, *Logos*. The teaching of Heraclitus in this respect has had its influence on the Christian religion, as expressed

particularly in the Gospel of St. John, but what was clear enough in the mind of the Greek thinker became afterwards, in the endless discussions of the Schoolmen on the "Word," reduced to something undistinguishable from sheer nonsense.

In Heraclitus we find also the conception of the Ether, although he uses the peculiar term "fire" to indicate what he means; and here it is worth noting that Lamarck afterwards adopted a similar expression of the same idea.

Democritus, of Abdera (460–357), is often linked with Heraclitus as being the "Laughing philosopher" whereas his predecessor was described in the exaggerated figurative language of the Greeks, as being always in tears. He is principally known to us as the great expounder although not the originator, of the Atomic theory; he did not develop his science into so many definite results of high value as Anaxagoras, but here and there he sends the plummet very deep.

Nearly two thousand years later we find Descartes, imitating the aphorismal style of Archimedes, and declaring: "Give me Space and Movement and I will give you a World." This notion really sprang from Democritus who also in his deep researches into the cause of things, touched upon the force of Attraction.

He recognized clearly the difference between the Subjective and the Objective, and he threw out the

basis of a rudimentary form of Psychology. He also suggested a simple form of the doctrine of Relativity.

Contemporary with Democritus lived one of the most prestigious of all the Greek thinkers—Empedocles, born at Agigentum (484–424). Empedocles, who was a student of medicine, developed more than any of the others except Aristotle the biological side of philosophy. He showed a clear distinction between thought and emotion, and he sought to localize the seat of these affections. He hit upon the heart as the chief organ of consciousness, although he said that various other parts of the body took part in the process.

The importance of the brain as an instrument of thought is quite modern and, with respect to the soul in whose movements emotion plays the main part, it is extraordinary to find how many different parts of the body have been chosen as its principal resort. One school of the Greeks lodged the soul in the tonsils, while Horace bids an inconstant nymph "inflame some other suitable liver." The Masais, to this day, give the calves of the leg as the habitat of the soul, the Papuans, the throat, while Descartes, who, as we have seen, derived many of his ideas from Democritus, reached a high point of scientific certitude when he discovered the seat of the soul in the pineal gland. His reasoning was impeccable, except indeed for one

default, namely, that it had no real basis at all. And in that respect it is comparable with nine-tenths of what we see given forth by our thinkers of to-day. The pineal gland had a position which was symmetrical with regard to both hemispheres of the brain, and Descartes perceived the soul seated as on a throne, but busily employed in directing the thoughts this way and that as they passed, the said thoughts resembling a special kind of the atoms of Democritus in being smooth and tangible extremely little things, and elusive to everything except this fortunate governance of the soul. The pineal gland, it may be said, is not a gland at all, but is the representative of a degenerated third eye which appears in one genus of the serpent family —Hatteras.

It would be possible to represent the ideas of Empedocles in a crude and amusing form. For instance, he believed that particles of matter were endowed with Love and Hate, but we must remember once more that the teachings of these great men have come down to us filtered through minds which were incapable of rightly grasping them.

Kepler, in our modern days, believed that atoms were moved by a directing angel, and this expression gives us a clue to the thought of Empedocles and makes us recognize how keen was the piercing of his intellect. Instead of the angel of Kepler at which we sniff indeed with our noses in the air,

we speak of "Attractive force"; but on the one hand, Kepler never gave to his angel any other faculty than that of attraction. It never occurred to him, for instance, to photograph this angel in bobbed hair and ballet-skirts; that feat has been left to the higher intellects of our own time. And Kepler might well turn to us and say: "What do you mean by Force?" And the answer is so difficult to give that men, keen in thought as Lagrange and Hertz, have sought to get away from the notion of Force altogether.

Hertz, in fact, at the time of his death was occupied with a work in which he hoped to expound mechanics without the aid of this conception at all. The term, however, is useful, but hardly more so than that of Kepler's angel, while this little consideration has enabled us to see that Empedocles, in endowing matter with love and hatred, had really touched upon the great problems that are still unsolved in the theory of gravitation and electricity.

There is something still more remarkable to be found in Empedocles—he had the clearest conception of what we now know as the Darwinian doctrine. True, this has descended to us only in a detached and mutilated form, but it is impossible to read the works of Empedocles without recognizing that one, who had so clear a view of the process of survival of the fittest, should not have intelligently grasped the whole principle of natural selection. He says

in fact that Nature is continually producing forms that vary from a certain normal, but that only those survive that are capable of adapting themselves to environment.

I here propose to touch for a few moments on a question which links these speculations with the problems which are ardently discussed at the present time. It might be asked, how was it that, if Empedocles held these ideas so clearly, they did not make a stir in the world comparable to that caused by Darwinism. The answer is that the relative importance of the doctrines of the great Greek and the modern Englishman depends upon accidental circumstances of history. The learning of the ancients became submerged in that thousand years of night to which we have already referred. During that period the Church held sway over the minds of men and not only destroyed what was true and great in the Greek teaching, but also emasculated the intellects of those whom it controlled. There had grown up, accordingly, a great mass of false notions, false science, false cosmogony, false ethics, false psychology, the fight against which provides a large part of the history of thought and of social movements from the days of the Renaissance.

Most of the controversies had been carried on by way of more or less direct reply to the teachings of the Schoolmen ; but Darwin's work, like that of Empedocles, might have been conceived and

carried on, as in fact it really was in the mind of Darwin himself, in quite another atmosphere; but by that time the forces of enlightenment had made great progress, and those who defended the old notions were intelligent enough to see that Darwinism meant an attack upon the Holy of Holies of their doctrine. They rose, therefore, as one man to defend the interests of the Church, but the force of evidence was too great even for their vast powers of resistance.

The second generation discovered that not only was Darwinism in the main true but that, properly interpreted, and especially if symbolic meanings be given to the old teaching, this new doctrine formed the surest buttress to orthodox religion. Pascal, in his day, twitted the Jesuits with the idea of truth changing its value as it crossed the Pyrenees, but these mutations of the eternal verities are small and timid compared to that wonderful transformation of a Truth which appeared so dread a danger to Bishop Wilberforce and his cohorts, and so helpful a friend to Bishop Wilberforce's successors.

Empedocles had not the good or bad fortune to raise such a storm. The gods in his day treated the human race with a certain indulgent aloofness and science was either true or untrue according to its merits. Empedocles, in his far-seeing vision, could hardly have conceived the day when the most

sacred thoughts and highest ideals of the human race must be dependent upon the versatility of morals and the suppleness of hypocrisy of which our modern teachers have given abounding proof.

That, however, is not the only reason why Darwinism has created a world of interest that has enhanced the reputation of its founder. The Greeks were not great experimentalists, and we will see afterwards that that was one reason of their subsequent decadence.

Empedocles did not found a school of research. He gave forth doctrines which could be appreciated for their scientific value, and there he left them. The great merit of Darwin, however, was not that of having hit upon the doctrine of evolution anew, but of having exemplified it in a thousand ways by his labours of observation and experimental research. He therefore gave an impulse to work of this kind which could be taken up and developed by men of mediocre calibre, for instance, University professors. An immense amount of research work was set in motion, and so, as always will be found if the matter be looked into narrowly, Darwin's fame was raised less on his actual intellectual achievement than on the nature of the opposition which he overcame, and also on the great amount of work, represented finally by vested interests, to which he gave the required stimulation.

The same social phenomena are observable in

regard to Mendel. Mendel was neglected in his day and he died broken-hearted. He was rediscovered, his work was found to be just of the kind which was ready to hand for elaboration in schools of research. And so it is by means of this sort, by pitting vested interests against vested interests rather than by the direct shock of scientific thought, that Darwinism is advancing. That is seen in places like Dayton, Tennessee, where any kind of research, or of high scientific thought has failed to gain a footing, where it is represented by poor vested interests, and where it has to meet the solid phalanx not only of ignorance and prejudice but of the material advantages which the world can offer.

One of the most interesting of the ancient philosophers was Eratosthenes to whom, indirectly, we owe the discovery of America. Eratosthenes not only knew that the earth was round, but he actually measured its circumference. He had heard a traveller say that, being down a well in Upper Egypt on a certain day, he had seen the sun overhead. That hint was sufficient for the philosopher to set him on the path of discovery. The well was, of course, in the direction of the centre of the sphere ; therefore by prolonging the radius of this sphere in the same direction he could ascertain the relative situation of the sun, the distance of the sun being assumed to be very great compared with that of the radius of the earth. He then ascertained

what inclination from the vertical he should give to a staff at his place in Lower Egypt, in order that it should point to the sun. This inclination gave him the angle corresponding to the arc represented by the spherical line between the stations in Upper and Lower Egypt. He then ascertained, though, as it afterwards appeared, not with sufficient accuracy, the actual distance between these two points. The circumference of the circle was the same multiple of that arc as 360° compared to the angle measured.

This work of Eratosthenes became known to Toscanelli, the famous Genoese philosopher, who made the reasoning clear to Columbus, and so gave him the assurance that by sailing westward he would eventually reach the Indies.

Eratosthenes, however, had found a result which was below the truth, and Columbus, therefore, thought the Indies were nearer than they were in reality. When, therefore, he first reached land he thought that he was on the outskirts of the Indies; hence the name "West Indies," which has been retained ever since.

This account is not that which is usually given with regard to that romantic voyage, for the goody-goody books have a mania for perverting truth, holding the immoral doctrine apparently that the face of truth should never be seen except under some ridiculous disguise.

The greatest of all the mathematicians of antiquity

was undoubtedly Archimedes, and to him we owe something which, though I say it with bated breath, seems to me of greater import than the discovery of America; not that it necessarily excludes that great boon for, inevitably, it would have led to it by another path. What I mean is that Archimedes had so far advanced in laying down the main principle and the true scientific method of investigation in mathematics and in physics, that he made inevitable the development of all that great body of theory and research which are the organic filaments of the life of our modern world. That is to say, all the great inventions, the great achievements and mechanical contrivances, all the various adaptations of electricity may be properly regarded as the graphic representation of particular cases in which these theories apply. It is these corollaries, the wonderful graphic forms referred to, which strike the imagination of the populace.

And the man in the street, whose wisdom there is a tendency to exaggerate, does not always inquire as to the origins of these marvels. Like the noble Lord previously cited, he wants results, not science. The noble Lord did not want the seed or the harvest, or the study of the forces of Nature, or the preparation of the material; he wanted only the loaf of bread that the baker's boy brought round in the morning.

But if we trace out step by step the subtle forces by which these results have been produced, we find

eventually that they had their origin in the curious thoughts that have floated through the brain of some solitary thinker, mind calling to mind across the seas and through the ages. The greatest achievement of the Renaissance, for instance, was not, in my opinion at least, the restoration of Greek literature, but that of the rediscovery of the science of men of the calibre of Archimedes and Aristotle.

Galileo became early acquainted with the writings of the Greek mathematician, and they set him on his own path of discovery. One of the most wonderful moments in the history of the world—I am not thinking of battles, slaughters, the surrender or the taking of towns, the carving up of empires or the investiture of kings or even of the foundations of false religions—I am thinking of the moment when Galileo, standing on the top of the leaning tower of Pisa, dropped two leaden pellets of different weights, and found that they reached the earth together. Galileo by that act destroyed the teachings that had prevailed throughout the centuries, based on mere dogma or on misconceptions of Aristotle. He found the ray of light through the thousand years of night, and took the first step towards instituting the modern world.

M. Painlevé refers to an earlier date—to the enunciation by Copernicus of the doctrine which overthrew the old Ptolemaic system, and gave us clearer conceptions of our solar world with the sun as the centre,

The work, however, of these two men is closely linked together and each found the source of his inspiration in the speculations and achievements of the Greeks.

Archimedes also was within touch of founding the science of the Differential Calculus. In order to ascertain the ratio of the radius to the circumference, he conceived the circumference first of all as being greater in length than the sides of a regular polygon inscribed in the circle and less than the sum of the sides of a polygon described about the circle. The next step was to get nearer and nearer approximations by increasing the number of sides. This was first called the method of exhaustion and, subsequently, the method of limits; and the act of proceeding to a limit with the number of the sides "infinite" is the essence of the infinitesimal or differential calculus. Centuries after, a great battle raged between the partisans of Newton and of Leibnitz as to who invented the Differential Calculus; intervening between Archimedes and these great mathematicians were many others, notably Fermat, and Pascal who pressed a little further to their inevitable conclusions the principles set forth by the Greek mathematician.[1]

[1] Lagrange attributed to Fermat the invention or, as Hermite would have preferred to call it, the discovery of the Differential Calculus. Certain it is that Fermat apprehended the principle, but he did not give to it the definite form and notation in the manner of Newton and Leibnitz. These notations are of real

One other mathematician who preceded Archimedes deserves notice, even in this all too rapid review, for having given centuries after his death a

importance, for, the English mathematicians, in consequence of the bitter dispute between the followers of Leibnitz and Newton, refused even to read the works published on the Continent in the Leibnitzian notation. Meanwhile the science had progressed enormously, and so a German mathematician was able to utter the jibe that: "English mathematicians stood still for a hundred years out of respect to the memory of their great fellow-countryman."

Then a band of young men at Cambridge, amongst whom Herschel was prominent, threw overboard the traditional silliness and gave a new impetus to mathematics in this country.

One of the difficulties in regard to mathematics has its origin in the great development of the subject. It is divided and subdivided into so many special domains that few, if any, mathematicians have covered the whole field. I remember once asking Henri Poincaré for some enlightenment in regard to a domain of mathematics known under the name of "Forms." He said he had never studied that subject at all, but referred me to Clebsch. Klein, however, makes great use of Clebsch in the exposition of problems treated by Poincaré. From this alone will be seen how extensive is the whole field.

The development of mathematics, although it has a life of its own, has generally been due to the stimulus produced by the study of physical problems, but now, on account of the complexity of the subject, a mathematician has little time for the study of physics. It was because he recognized how difficult it is to gain a mastery of the mathematical instrument, that Hermite resisted the temptation to make a study of physics at all. A physicist, on the other hand, is often insufficiently equipped in regard to the mathematical instrument. Yet the combination of the two seems to be more and more advisable as the science is developed. Here then is an argument in its favour for the organization, classification, and simplification of mathematic forms.

reply to the question : What good is it ? This was Apollonius whose special work was that on the Conic Sections. He pursued his studies in the true spirit of science for their own interest, but when Kepler entered upon his researches as to the movements of the planets round the sun he received inspiration and guidance from the previous results of Apollonius. Kepler determined the orbits of the planets, and then sought to ascertain the law which governed them. This was subsequently discovered by Newton, and enunciated in his law of gravitation.

Here, however, we meet once more with that pernicious tendency of certain people to misrepresent facts, and so we have the story of Newton and the apple. Newton did not need such stimulus to thought for already Kepler had tried several theories and the wonder rather is, that having gone so close, he did not strike upon the veritable law.[1]

The English philosopher's task was really that of solving a problem which, with all the data given

[1] In this case, as in nearly every instance of advance in science or invention, the sources are numerous which lead to the final result.

During the Dark Ages, for example, the philosophers spoke of centrifugal motion ; they had observed the tendency of bodies in motion to fly off at a tangent, as in the familiar experiment of swinging a stone at the end of a string. Being unacquainted with the veritable laws of motion, they explained the occurrence by saying the body yielded to centrifugal force. That is an example of an explanation to which the somewhat barbarous term "*ad hoc*" is applied. It is, of course, not a real explanation at all, but it serves to check further curiosity and generally leaves the reputation of

to him, had been reduced to one of mathematics, and Newton, like all the others, was the heir of Hipparchus, of Archimedes, of Apollonius.

I have left out of consideration for the moment the two most famous of all the Greeks—Plato and Aristotle, and I can only touch on them now to draw out that moral which is really the main theme of this book. Plato embraced a wide scope of thought, but the subject which he had pursued with the greatest tenacity of research was doubtless mathematics, and after his death it was the mathematical side of his teaching which had most vitality; that is to say, in the years immediately following. At a later period, however, the Schoolmen seized upon the more obscure of his doctrines and, in this happy hunting-ground, they dissipated their talents for centuries, and left their malign influence to obfuscate the brains of many of our most famous and most authoritative thinkers of to-day.

One reason of this is to be found in the fact that Plato was not only a thinker but an artist, and the

the philosopher unimpaired. We shall afterwards see that many of our men of science of to-day bank largely on the "*ad hoc*." Galileo was the first to point out that the so-called centrifugal force imparted to bodies by reason of their position on the earth's surface was really due to the rotation of the earth. He made the mistake, however, of supposing that this tendency was counteracted by gravity, no matter how small this might be. His reasoning was subsequently taken up by Huyghens, and in his speculations he had got so far that the next step was that which Newton supplied by the discovery of the law of gravitation.

special field of his art was that of the literature which, in all its charm, he has bequeathed to us. The Greek language was of itself in part responsible for this effect, for truly greater than the Pyramids or the massive walls of great cities or all the achievements of all the ages of brute force, was the elaboration of that wonderful instrument of expression, so strong and so supple, so keen and light, and yet so fertile in resource, the language of the Greeks, approached only by that work of art, elaborated through the centuries and brought within our time to a high polish of perfection, the language of the French. The glamour of Plato's style has masked the weakness of his arguments, but that has rather enhanced than diminished his fame.

Throughout the Dark Ages the recorders have been men of an education too exclusively literary and so, while they either belittled or misconstrued the works of the scientific thinkers, they gave an exaggerated value to Plato. The vice has been perpetuated in our Universities, and it has happened in the history of the world that the influence of Plato has been, so contrary to his real spirit, retarding and obscurantist.

Of Aristotle, the very type of scientific thinker, something parallel may be said. For ages his teaching was perverted, and it was partly on the authority of Aristotle that the Cardinals thought to abash Galileo and to deride his work. Every

thinker has one strong side, round which the other parts of his system of thought revolve ; and Aristotle was essentially a biologist. He was not a great mathematician and, consequently, he was not especially strong in physics. In his marvellously comprehensive mind, he saw that science derived its main interest in the illumination it gave to human life and conduct. He bore a lamp in his hand which revealed, within its limits, the form and structure, material and psychical, of the world in which we live, and with that illumination he brought to us guidance in the sphere of Ethics. But in order to establish a true ethical theory he saw the necessity of ascertaining the ground on which our reasoning rests ; that is to say, he searched for a true basis of psychology, and he recognized that if that could be found it would have the same relation to the whole body of thought, in the more distinctively philosophic realm, that mathematics has to the field of physics.

Again, the mind of Aristotle was not in especial strong in the field of psychological analysis. He sought for the foundation of his system as deeply as possible and he exhibited as the elements of thought the Predicaments which, at a later day, Kant transformed into his Categories.

But though there is evidence that Aristotle sought for a principle of classification which would enable him to demonstrate that his Predicaments were

sufficient to cover the whole field, that they were veritably basic and, moreover, not redundant, he failed to find that principle of classification. It is said that he searched for his Predicaments in the current works of grammar, but that is simply ridiculous. There was no mind previous to Aristotle so keen, so truly endowed with the scientific spirit, so impressed with the necessity of classification, so well organized ; and it is apparent, moreover, that his Predicaments, imperfect as they are, bear the mark of his own genius. But the problem itself was too obscure and elusive, and Aristotle left it unfinished and proceeded to his developments. His Ethics is a work of marvellous creation. It is comprehensive, philosophical in conception, and it appeals continually, even if tacitly, to the test of Nature ; yet, after all, it is only the expression of the opinions of a highly enlightened mind, supported by a genial and well-balanced temperament.

Amongst those, however, who followed Aristotle, it was rather the weak parts of his whole philosophy which were attractive, and in the subsequent teachings the simplest problems of physics, for instance, were obscured by such conceptions, impossible to realize because they had no veritable meaning, as "proper," and "improper" motion. It seems astonishing at first sight that thinkers should continue for centuries handing down from one to

another meaningless expressions and false doctrines, and that when at length Galileo arose, and even when he had made his irresistible appeal to Nature, there should be still found men of the highest intellectual eminence, as measured by the prevailing standard, who denounced him, who persecuted him and who sought to obliterate his work. I would say that this might appear astonishing, did I not find something more astonishing still, or what will appear so to those to whom the suggestion is new,—that in the spheres of Psychology, of Ethics and especially as in as far as these bear the indications to new social adjustment, we have the same false teaching, the same spirit of intolerance and reaction, the same pompous display of great authority, of high-sounding names, of convincing appeals to false authority; the same wickedness in resistance to the truth, the same perversion due in part to ignorance, in part to prejudice; the same virtuous feeling in the perpetration of abominations, the same appeals to supposed high rectitudes, the same commission of sins against science, the same difficulty for a work of simple truth to penetrate when it bears the promise of destruction of the vested interests of falsity. The reign of the Cardinals is still with us. It is to be found at our great Universities, which are the very fortresses of delusive teaching. It thrives in the spirit of the British Association; it lives in the great magazines

of thought, and in the great organs of the Press it is like the air we breathe.

This I know is not the manner in which our scientific world is usually regarded. Scientific men cast their eyes over the history of their own science, and they note that, at every turn, the fiercest obstruction, not of argument but of authority, was offered to those bringing new advances which broke off at a more fundamental level than the theories in vogue. And then they rise from such reading and with smug satisfaction congratulate themselves on having advanced beyond that state of affairs. But they forget that at every stage in the past their predecessors anointed themselves with the same oil of self-righteousness ; their predecessors, even the most obstructive, were generally accessible and helpful to the furtherance of ideas, on the condition always, of course, that these ideas agreed with their own teaching. So it is to-day.

In some respects I wish to be more circumstantial. Of quite recent years progress in certain sciences, such as Physics and Chemistry, has been remarkable, even brilliant ; in those sciences which are capable of being more or less restricted to technical forms and where the results can be tested by experiment. But again it is in the application to the whole body of science, in that end towards which science even in its ever-widening scope, should seek to converge its rays, that indeed which responds

to the conception of Aristotle, the philosophy that deals with matters of Ethics or human destiny, of government or, in the true meaning, of religion, —there the cloven foot is still to be found.

In following out the achievements in the new developments of Physics, for example, I have at times been swept off my feet in sheer admiration of the keenness, the intellectual energy, the zest of research, the splendid results, and I have taken off my cap to the great men whose action here has been so successful. But few even of these, by reason of their excessive specialization, possess any great general—I was going to say "culture," but I find a sudden repulsion to the word, and this perhaps less for its associations with Germany than with the massive hypocrisy of our own Universities—I say, then, that few of these men possess a true intellectual development such as will enable them to take within their scope of vision the movement in all the fields of science, to see how their own work lies in that total sphere, how it is related and co-ordinated to the onward march; and particularly here I insist again and again, in how far it is able to give illumination to the problems of Psychology and Ethics or, to use a word that they themselves have done so much to debase, of Philosophy.

CHAPTER TWO

MATHEMATICS

MATHEMATICS is the science of exactitude. An old mathematician whose name at least remained conspicuous at one of the Universities at which I have studied, used to say : " The first thing you learn in this class is Precision ; and the second thing you learn is Precision, and the third thing you learn is Precision."

Some of the students certainly complained that they learned not much else from that learned but too highly-strung professor. And as showing how little practice depends on theory at times, the professor on one occasion tore off the corner of a piece of paper and, running excitedly at one of his students, who after all was not without promise, bade him write there " everything he knew."

Mathematics is a subject which I have pursued in my own way with zeal throughout my life, but at first with very little encouragement from my professors ; so that for a long time, influenced—and here is a little point of psychology to meditate upon—by the uninterrupted sequence of bad examples, I had concluded that skill in mathematics was a gift offered by the Deity as a consolation for

weak voices and cracked tempers. I was interested afterwards to learn that d'Alembert had a somewhat similar opinion, for he has an amusing little note on the "Dryness of Spirit" of mathematicians. Even the great Euler he criticized on these grounds, although he came away mightily impressed by the scope and power of the Swiss mathematician. "That man is not amusing," he said, "but he knows mathematics." His style was not even the natural expression of Euler for, in his own family circle, after finishing some laborious calculation, he would throw himself with great zest into a Punch and Judy show. In company, however, he was apt to be silent, and, a lady who knew him well having reproached him on that score, Euler replied: "Yes, but I have just come from a country where those who speak too much lose their heads."

Euler had in fact recently returned from Russia where he had been invited to the Imperial Court. He had been treated with great honour, but he had also learned to know the limits up to which science may be patronized by the rulers of the earth.

Long before the time of Euler, Descartes had been invited to the Swedish Court by Queen Christina, who was so eager to know the gist of his science that she had the philosopher in attendance upon her at five o'clock in the morning, and so caused his somewhat untimely death.

I cite these little matters to indicate that mathematics which now seem to most people an austere and sterile study, was once as fashionable in the society which calls itself the best as Jazz-dancing or French revues in our time. There has been a succession of " fashions " in science quite as marked as that in Spring bonnets. During the Dark Ages the favourite science, if it can so be called, was that of metaphysics, of which we have already noted one or two of the problems. Afterwards, following upon the impulse which Descartes himself had given to the science, mathematics came into favour. At a still later period, in the days of Laplace and Lagrange, mathematics had a still greater vogue, and as one surprising result after another was brought to light by the great mathematicians, society became again enthusiastic and the world felt that the delicate antennæ of this wonderful science were beginning to touch on the very inner secret of things.

This enthusiasm was in part due to an illusion in regard to the nature and not to the power of mathematics, for Henri Poincaré, one of the brilliant mathematicians of all times, has spoken in a much more temperate and nonchalant manner of the real meaning of that instrument.

The purpose of this present chapter is to show that in this subject which, above all, demands exactitude and closeness of reasoning, and which,

as a matter of fact, has been served by some of the greatest minds that have been produced in the history of the human race, in this science, I say, there is no absolute certitude. In a chapter of my PSYCHOLOGY I have sought to ascertain what are the ultimate sanctions of our belief in any statement, and I have found that there is nothing which gives us an absolute certitude.

I will not delay, however, now on these somewhat abstruse and subtle thoughts, but at a level in which results are more patent I will give a few indications of errors in mathematics due, not to the mistakes of average men, but put forward by the greatest masters of the science. During a certain period of my reading I collected notes on the errors of mathematicians of the calibre of Newton himself; Euler, Lagrange, Laplace, Abel, Galileo, Cayley, Sylvester—names of the highest prestige. How, then, can I assert that these men were in error?

It would be too long, it would demand too much space, to give any adequate proof, so that I content myself by saying that either the errors have been recognized by the authors themselves or they have appeared in the results, or they have been pointed out by succeeding mathematicians of no less calibre, who have made appeal in their reasonings to more fundamental truths and to more cogent arguments. That being so, I will link on with what we have noted in the first chapter about the fostering of

science by the Greeks, in order to reply to a possible question as to how their work of development was broken short and left throughout the ages without a sequel.

Study here brings out one or two interesting psychological points.

The Greek thinkers were in the main rich men, as riches counted in those days, and they were served by slaves ; accordingly they grew up with a certain contempt for manual labour—a state of mind that has not entirely disappeared in our own day. They regarded speculation as a far higher exercise of human faculty than measurement, and in this respect it must be remembered that the instruments of measurement were rudimentary and gross. The Greeks desired precision, and they sought as far as possible for clarity of expression; in consequence of this, again, they neglected what we now call "minus quantities" and also the irrational numbers, that is to say, numbers represented by roots or which, worked out in fractions, showed a series that does not terminate. They never even contemplated what we now call "Imaginaries," the square-root, for example, of minus one.

It was this disposition of mind which produced the comparative neglect of Algebra for, though that science was known in a rudimentary state in the later days of Greek development, yet even Archimedes never reached the point where he

could state so simple a proposition as that $a^m \times a^n = a^{m+n}$. A contemplation of such a formula, however, might have put him on the track which ultimately led to the invention of logarithms. When men, however, have pursued certain modes of thought for a long time, their minds become pervaded by a sense of etiquette which prevents them from breaking out of the grooves, and this is as true of science as it is of poetry where, as is seen in French literature, a series of conventional rules may kill the spirit of poetry itself.

Then again the Greeks were generally indifferent to invention or even to the graphic representation by models. They were deluded by a certain spiritual pride, though represented in a more genial sense than in some of our Universities where it is cultivated in a colder form. These subtle barriers to further mental development were amongst the causes of the decadence of the Greeks; they fell, and that decline is one of the tragedies of human history.

Speaking to a famous European biologist lately, I received the suggestion from him that, after all, a race may arrive at a point when it has put forth all its power; and so the Greeks had given the measure of which they were capable. That, however, is only in part true for, in addition to the factors I have indicated, which also prevented the physical expansion of their nation, there were many

others, such as their subjection to the power of Rome.

Such algebraic methods as the Greeks possessed had little apparent relation to their geometrical science. It required a fresh effort of genius to show the connection between these two branches—and that brings us again to Descartes, a philosopher who had exiled himself to Holland in order to think the more peacefully—"I value my liberty," he said, "more than all the honours that kings or emperors can confer."

Lying in bed one morning, as was his wont, in deep meditation, he suddenly noticed something which made him leap out of the sheets. It was simply this—that three walls of the room intersected at a point; that is to say, at one of the corners of the room. Many people had seen that before, but a great deal depends on the "seeing."

Descartes had remarked that an object such as a bowl on the table was a certain distance from the floor, and at another distance from one side wall and still another from the other side wall, and that these distances could be expressed by numbers according to the unit of length adopted.

The next step in thought was that if the bowl were removed, but if the numbers had been known, it would be possible to rediscover the position of the bowl by measuring up from the floor and from each of the walls, according to the respective

numbers given. These numbers were, in fact, the first representations of what we now know as Carthesian co-ordinates. If we know the co-ordinates of any point in space we can fix that point.

Carry the suggestion one step further—imagine this system of co-ordinates, not necessarily now fixed to the room of Descartes, but represented in a system of any three planes meeting at a point, and imagine a regular ellipsoid so placed that the centre of the figure should coincide with the point of meeting of the planes, or centre of co-ordinates as we call it. Now as each point of the figure can be determined by its co-ordinates and as the figure is itself regular, we should expect to find fairly simple relations between the co-ordinates of all the points.

Descartes perceived at once that that was the case and so, by use of his co-ordinates, he was able to represent symmetrical figures of Geometry. In this way, then, he was able to apply the principle of algebra which, since the days of the Greeks had been revived and developed, to the study of Geometry.

Now it so happens that the main part of all natural phenomena is revealed to us in fairly simple geometrical figures, and Descartes himself had developed the study of optics ; by this new resource of his co-ordinates he was able to apply the principles of algebra with their clearness, flexibility and precision, to the study of physical questions.

Soon after his time the principles of the Differential Calculus were established and an immense amount of mental energy was released in the study of these problems, and of this effort we have reaped great results although we are still perhaps only at the beginning.

For instance, when Clerk Maxwell leapt to the conclusion that electrical phenomena were due to the undulations of the ether, he was able to apply at once to the study of these phenomena the great mathematical apparatus which had been developed since Descartes's time by a number of keen thinkers, including Thomas Young and Fresnel.

The reproduction by means of the undulations corresponding to electrical effects of the phenomena of Light,—reflection, refraction, interference,—such as were carried out by Hertz, launched thinkers on a path which led, one might say, inevitably to the discovery of "Wireless."

The early achievements of mathematical science did not escape the notice of the great authorities of the time in Church and State, though the new science had to struggle hard before being admitted into the University curriculum. It came in first under the skirts of Theology—the word "Wrangler" remains as in indication of that origin. In France it was long regarded with deep suspicion. I have culled from various sources arguments for its admission which might seem sheer lunacy, did we

not find alive to-day, though under other names, corresponding ideas.

One of the arguments in favour of mathematics was that of a certain sanctity inherent in its formulæ. It is quite remarkable to find how many thinkers during the last few centuries have found in the propositions of mathematics a proof of the existence of God. If all they believed were true, the Creator of the Universe, omniscient and omnipotent should rather have appeared little dependent on such support.

Here again a nice psychological question is involved; it will be found invariably that, when a thinker of some temperamental fervour pursues two paths of thought—whether it be neo-Platoism and Christianity or, as in the old days soon after Descartes had stirred the world, mathematics and religion—there should be a desire to see the two conceptions united. Thus we find a Jesuit priest, Pardies, in 1673, deriving this proof of the existence of God from the existence of asymptotes. An asymptote may be roughly described as a line which tends continually to approach a certain curve but never touches it. If one imagines two straight lines crossing each other, say, at right angles. Then it is possible to draw within the space included an hyperbola of which these straight lines are the asymptotes. Now the space included between the hyperbola and the co-ordinates, that is to say, the two lines in question, stretches away in the direction

of the asymptotes to infinity; but yet remains less than a certain finite amount. This is an interesting fact familiar to students of mathematics, but it required the genius of the good Father Ignace Pardies to supply the Jacob's ladder by which we ascended from this mathematical fact to the contemplation of the Deity.

A few years later another learned priest beat this achievement, for he waxed into rapturous enthusiasm over the Divine essence of a mathematical point and, on that basis, revealed to us a whole spiritual world. A little later still another priest—Father Rohault—in 1682 discovered that religion and mathematics were in their essence closely interwoven, and found that the salvation of the soul might be sought in geometry.

These speculations recall to mind those not only of Pythagoras which we have already noticed, but of Plato and Herbert Spencer. Plato was so struck by the fact that, in the interpretation of natural phenomena in mathematical form, one inevitably came across the sense of harmony, that he expressed the matter in one of those striking aphorisms of the ancients: "God geometrises." Herbert Spencer on his part, really a good devout bourgeois soul, was entranced by the reflection of the surety and the generality of mathematical formulæ, and he writes on this score a little sermon of high spirituality. Darwin also has an appreciation in

the same order of ideas although expressed with greater reserve. He said that mathematics seemed to endow one with something like a new sense.

The fruit of this kind of eulogy of mathematics was gathered much later, and in 1738 we find still another learned priest approving of the introduction of mathematics into the University of Paris, so that this science now took its place beside that of logic and of physics.

What was the physics without mathematics we may crudely guess, but all this which seems to belong to the infancy of the world, comes, 1738, within touch of our own day.

Meanwhile mathematics had been fighting for its existence. D'Alembert's remarks about the dryness of soul of mathematicians were somewhat too sweeping. He himself was an example of a man endowed with high imagination and fiery zeal combined with a delightful playfulness of spirit and wide range of sympathies. And yet he was one of the clearest thinkers in his day in the developing science of mathematics. But long before the time of d'Alembert mathematics had stirred the souls of men. The founder of the Cartesian system had already been plunged into hot arguments with Fermat, who had responded with still greater fervour, so that Descartes, who was certainly not wanting in temperament, summed up the situation by saying : " M. Fermat is a Gascon,—I am not."

Then later came the Bernoullis, a famous and wonderful family who occupy in the sphere of mathematics a position analogous to that of the Bachs in music. The whole family,—father and son, grandson, uncles and nephews,—pursued mathematics with a holy zeal, the exuberance of which sometimes escaped into less authorized channels. Differences as to the interpretation of formulæ caused splits in the family as deep as those of religion. John Bernoulli cast his brother James out of heart and home because he had anticipated him in publishing a certain result. At a later period Daniel Bernoulli reproached Euler, who was then at the Court of Frederick the Great, for being led away by lesser things as, for instance, by the influence of the Court, which diverted his mind to politics and to metaphysical speculations. Daniel was grieved that his master should, on such trivial grounds, desert the "Divine things" of algebra.

John Bernoulli with the zeal of an Old Testament prophet used to fling out his objurgations over Europe. Those were the days when great mathematicians challenged each other, like heavy-weight boxers in our time, carrying on, moreover, a similar wordy warfare in what corresponded to the Press. John Bernoulli was jealous of Newton but, on one occasion yielded him great homage. He had sent him a problem in a more or less defiant way, and

Newton had received it when tired after his day's work at the Mint, but had found the solution before retiring to rest. He sent this solution to Bernoulli, unsigned, and the great Johann after looking through it, cried: "That's Newton! I know the lion by his claws!"

Bernoulli on one occasion, however, turned the tables on the great Englishman, for he discovered that, in one of his calculations Newton had committed an error in regard to the estimation of the resistance of the medium in virtue of which was determined the curve described by a heavy body launched into the medium. The Bernoullis who discovered this error of Newton's as well as those who followed them, fell into an error themselves in ascribing it to a certain failure in calculation; but Lagrange pointed out that the source of the error was quite otherwise than they had supposed. In his *Théorie des Functions*, 1813, Chapter 4, he devotes an extraordinarily interesting passage to the discussion of this matter, and the reading of this brings to view the delicate psychological questions involved in a complete grasp of mathematics. The sequel to Bernoulli's intervention was that Newton, while ignoring the attack at the time, quietly inserted the necessary correction in a subsequent edition.

It might at first sight be thought that, in a subject where precision is so expressly demanded,

and where the steps are so closely consecutive as in mathematics, there would be little chance of error. This is, however, far from being the case and, in fact, the demand for entire rigour in demonstration did not arise until mathematics had acquired a great development.

The two great champions of rigour in the early days were Cauchy and Gauss. On one occasion, during a meeting of the Mathematical Society in Paris Cauchy, then a comparatively young man, read a paper on the necessity of rigour, devoting himself especially to the representation by means of series. He pointed out that this mode of expression might lead to error if the series were not convergent, and he emphasized, therefore, the need for testing every series employed in regard to its convergency. Amongst his auditors was the famous Laplace, ripe in years and loaded with honours. As he listened to Cauchy's exposition he began to grow pale and as the young mathematician proceeded, he became more and more disturbed, until at length when Cauchy had concluded, Laplace, blue with fear, rose and rushed from the room. He proceeded straight home, and locked himself up in his rooms for three days. During this time he re-examined all the series which he had employed in his *Mécanique Celeste* and other works, and at length emerged content for he had found that all these series were convergent.

In this respect he was more fortunate than Euler who, though a man of prodigious fertility and extraordinary mastery of his instrument, had not sufficiently considered the need for rigour, so that many of his conclusions are unjustified.

Euler figures in a famous controversy which, though it began originally on a question of mathematics, grew at length into such proportions that it shook the foundations of a throne.

Frederick the Great, in a laudable but unsuccessful attempt to make Berlin the metropolis of Europe, a home of sweetness and light, had gathered round him many of the famous men of the day, and these included as well as Voltaire, Euler the Swiss, and a great French physicist, Maupertuis, whom Frederick made President of the Berlin Academy.

Maupertuis was an excellent man in his way, having greater qualities than are usually demanded nowadays for such exalted positions and not more than the proper degree of that pomposity which is so carefully cultivated in exalted circles, and which is so detrimental a possession. In the course of his researches his mind was much intrigued by the problem of Least Action. This may be roughly indicated thus: If a varying quantity of energy move along a path and if the product be taken at each element of the path of the quantities representing the energy and the element of the path, and if all these be added together, or integrated, then it

is found that this integral is least when the path is that which would be naturally taken by the body when the path was determined by the actual given forces.

Maupertuis read into this a wonderful conception and, still following the line of thought of the good priests whom we have already cited, he put the fact forward as a proof of the existence of God. The question was taken up by a mathematician named Koenig who was not so famous as Maupertuis, but who had a better sense of mathematical logic.

The intervention of Koenig offended Frederick not so much that he himself was on the side of God, as that he felt his dignity hurt by reason of his President of the Academy being assailed. In these circumstances Frederick called in Euler, and that great mathematician was complacent enough to try and cover up the situation under the ægis of his own authority. Voltaire, however, became apprised of the dispute and, although not a mathematician, he was able to exercise his own clear intelligence in the matter, especially as he suspected the deficiencies of Maupertuis and was already convinced of those of Frederick. He therefore championed Koenig with all his zeal and that mordancy of wit which made him feared by his enemies. He turned Frederick himself into ridicule, and the relations between the two Powers

became so strained that a diplomatic rupture was inevitable.

In the meantime, a young Irishman in the French Military Service, Count d'Arcy, had published a couple of papers in which he proved again that d'Alembert's idea of dryness of soul was not an invariable function of mathematics. D'Arcy's papers are witty as well as illuminating, and he showed that according as a convex or concave mirror was interposed in the path of a ray of light, Nature became either extraordinarily economical or widely spendthrift ; so that neither she nor God, as defined by Maupertuis, could justify the eulogy and homage which his mistaken conceptions had bestowed upon them.

The question of "least action" is usually treated nowadays in a somewhat off-hand manner, and perhaps without full illumination to the base ; but that it is still full of live interest for a mathematician may be found in reading the memoir on the subject published by the German mathematician, A. Mayer, and also in some papers by an English mathematician not long deceased, Philip Jourdain.

The history of mathematics shows numerous quarrels between mathematicians in regard to the rigour of argument or, in some cases, with regard to the justification of methods. One of the pupils of Gauss, von Staudt, had a disinclination

to use algebraic forms greater even than that of Apollonius himself. He elaborated an extraordinarily interesting system of demonstration by the exclusive use of figures, principally straight lines and planes; within the scope of his exposition he has given us not only a powerful mode of investigation, but he has also made the matter almost intuitively clear. Von Staudt was little noticed during his lifetime, but the celebrated French mathematician, Darboux, shortly before his death, said that he was more and more attracted to von Staudt's methods and that he was greatly impressed by their importance.

Steiner, a Swiss mathematician, was of the same school as von Staudt, though he did admit certain elementary calculations. He was contemporary with Plücker whose mathematical work proceeds from that of Descartes, by giving it an extended generality. He takes the line instead of the point as his elemental form. Plücker evolved a powerful form of analysis, and his work, developed and elaborated by Felix Klein and Sophus Lie, has produced the great bulk of the advanced work of the higher mathematics which interests us to-day.

Steiner, however, was very unappreciative of this new branching out by Plücker, and he threatened to cease to write for one of the mathematical journals if Plücker continued to be a contributor. As a matter of fact, Plücker was forced to restrain

his mathematical activities so much that a great part of his work was given to the public only posthumously.

Grassmann was another German mathematician of profound views and highly original style, whose work is now recognized as having a high value, but who found it so difficult to find any interest in it during his own lifetime that he abandoned it altogether, and devoted himself to philological research, in which he soon gained a high reputation.

Lagrange, whose mathematical work has the veritable stamp of genius, began to shine already in the forefront of the science at the age of eighteen, surpassing even the great Euler by the greater power and generality in his treatment of the Calculus of Variations. Yet in this very subject he has not been free from reproach on the score of rigour. It is interesting to cast the eye for a moment over the course of development of this subject during a hundred and fifty years.

Newton, in 1686, treated the problem of the fall of a body in a medium of varying resistance, but he did not work by variations. Ten years later, John Bernoulli discovered the form of the curve between two points at different levels which allowed the descent of an object along the curve in the shortest time. This is the famous brachistochrone, which is really a cycloid, and John Bernoulli tells us of his amazement when he first made that

discovery. He also worked without the assistance of the Calculus of Variations.

A year later, his brother James had a glimpse of this system, and he used methods of maxima and minima. Euler, writing in 1744, developed the method, and exhibited it in numerous examples.

Then Lagrange, in 1762 and onwards, treated the whole subject in masterly style. Legendre, however, in 1786, showed that certain reservations were necessary to complete and finish off Lagrange's work; and Jacobi, in 1837, extended Legendre's researches.[1]

Lagrange had always showed himself very sensitive with regard to questions of rigour; one little point, for instance, which seemed to him paradoxical, hurt him, as he says, for years until at length by diligent searching he discovered the source of this mathematical neuralgia, and by so doing gave new illumination to his studies in differential equations. But Lagrange himself, after he had reached the veteran stage in the service of his science, almost jumped out of his chair when Fourier, the author of a brilliant work on the theory of Heat, submitted to him the expression of a function by means of a new form of series.

[1] This is, of course, not meant to be more than a brief indication of the gradual development, particularly in regard to exactitude, of the theory of variations. The question has attracted the attention of a great number of other mathematicians, and the interest of the subject is not yet exhausted.

Fourier assured him that this series permitted the expression of any function whatever, and it was at this point that Lagrange became so excited.

"What!" he cried. "Any series? It is not possible!"

It was possible, however. Fourier's work was subsequently submitted by the Academy of Science to a small Committee, including Cauchy. They reported favourably, but with certain reserves in regard to completeness and rigour of proof. Fourier took umbrage at these restrictions. So much so that they seemed to outweigh in his mind the high eulogy of his work contained in the report. These restrictions were not uncalled for, and ever since that time Fourier's work has been the object of attention to scores of mathematicians, amongst whom Professor H. Carslaw, of the University of Sydney, has devoted a volume, and numerous other writings to the subject.[1]

There have even been times in the history of mathematics where the great mathematicians have been at a loss to know whether a process of reasoning was admissible or not. Riemann, one of the greatest of German mathematicians, demonstrated a certain theorem, of which one of the applications is to questions of potential in electricity, by the

[1] Dirichlet and Riemann believed that Fourier's Series would represent any continuous function at all points, but this conclusion was adversely criticized by Dubois-Reymond and Schwarz.

use of the principle of Dirichlet, this principle depending on an intuitive perception of certain relations.[1]

Weierstrass declared that the demonstration was not rigorous ; the mathematicians ranged themselves in two camps. The battle continued for years, and though it is now settled in favour of Dirichlet and Riemann, it is still a matter of great attraction to mathematicians to work out a new proof of the famous principle.

These intellectual struggles have been all to the advantage of mathematics. I cite them in order to advise the reader that even in matters of demonstration, and in critical points as to the origin and ultimate sanction of processes, mathematical reasoning is liable to error.

These are matters of real importance, and a little anecdote told me by no less a person than Henri Poincaré, shows to what a degree that aspect is recognized.

Kronecker, a brilliant German mathematician, whose *forte* was the theory of numbers, was the father-in-law of Schwarz, no less brilliant in the domain of the theory of functions. Kronecker was in Berlin at that time, if my memory serves me,

[1] The objection to Riemann's application of Dirichlet's principle was formulated by Weierstrass and Kronecker, amongst others, on the ground that it applied methods of Calculus to functions which have not been demonstrated as amenable to that treatment.

and Schwarz in Breslau, and Kronecker was in the habit of posting useful presents to the Schwarz family—stockings, or pinafores, and objects of that sort. Now Schwarz had sent to Kronecker the solution of a problem on which he had been working for some time, but instead of receiving the word of praise that would have refreshed his over-tried and thirsty soul, he found a series of stringent remarks on the score of rigour. Without rigour, you see, there can be no health in mathematics. Schwarz said nothing at the moment. The blow was too severe ; but when on the next birthday the usual packet of useful presents arrived, Schwarz gave vent to his fury, and his reply to the criticisms of Kronecker was shown in the expeditious return of the whole cargo of haberdashery. It might be objected that even that demonstration lacked rigour, but it is some evidence that not all mathematicians are afflicted, as d'Alembert thought at one time, with "dryness of soul."

The life of Evariste Galois exemplifies that point. Contemplation of that brief career has a sort of fascination for me, for Galois, one of the most brilliant intellects ever vouchsafed to earth, perished after a turbulent existence at the age of twenty-one. He was an ardent Republican in the time of Louis Philippe, and he was locked up in prison for the part he had taken in a political demonstration. While he was there a Royalist officer pro-

voked him to a duel, the immediate cause being, it is said, the smiles of a pretty waiting-maid who brought the prisoners their food. Galois accepted the combat, but he had the presentiment that his "number was up." On the night before the duel he explained briefly, but clearly enough, the lines on which he had been working ; this document, known as the "Testament of Evariste Galois," led to developments, including that of a theory of groups, which is still in its first vigour.

Galois had never been recognized properly by his teachers, partly because his modes of thought were both profound and original, and he passed out of the École Polytechnique with an unfavourable note.

Still more sad, if possible, was the fate of another young mathematician, the Norwegian, Niels Abel, an astonishing genius who may be fairly called the Keats of mathematics.

Abel was the son of a poor Norwegian pastor, both his father and mother having been alcoholics, as I was told on high authority not long ago in Sweden. He was a young man of extraordinary endowment and lofty ambition which, however, had the minimum of mere personal pride. He made the long pilgrimage from his native town to Paris, in order to converse with the leading mathematicians of the day and, at length, in his twenty-fifth year, sent to the Academy of Science a Memoir on a

subject which is now identified with his name, which was an extension of a branch of the science known as Elliptic Functions. This was one of the finest achievements in the history of mathematics, and it has since been the groundwork on which has been built a great system of study which is still in course of development.

Abel received no reply to his Memoir, and at length, reduced to poverty, deeply disappointed, and already afflicted with phthisis, he set out in winter to return to his far Norwegian home, on foot. He lived but a short time afterwards, almost unknown and unrecognized. A few months later, however, a small delegation from the French Academy arrived in Norway to offer him their tribute. Abel was dead.

Cauchy, when asked afterwards how he had failed to see the importance of this Memoir, gave certain excuses which do not seem to have much scientific value, but which are very interesting, because they reveal the influences which cause opinions to be formed. Cauchy said, in fact, that the Memoir was written on rough paper, and it did not bear the insignia of any University or other learned body. Moreover, Abel had called upon him once, and he had seen a modest and rather gauche young man, evidently not accustomed to society. Cauchy, it may be said, was a *grand seigneur*, while Abel wore rather clumsy, square-

toed shoes, and he did not express himself in good French. These arguments against the validity of a mathematical exposition do not seem quite conclusive, but it would be unfair to conclude that Cauchy was either a fool or a bad man; on the contrary, he himself was a man of brilliant intellect and of conscientiousness pressed to a high degree of scrupulosity. When he did read Abel's Memoir with attention, he recognized its value at once, and did everything in his power to rectify his first omission. Cauchy's attitude was simply an expression of that "morgue académique" which is so prevalent a disease at centres of learning that only minds of real innocence or high power escape.

Airy, the astronomer who had great fame in his day, affords another example of this spirit. He had received the calculations of Adams, indicating the position of the new planet, Neptune, before the publication of the work of Leverrier, but he put it aside without looking into it; and so it happens that as far as priority is worth, that prize was lost to this country and given to France.

On another occasion Airy visited Sir William Hamilton, the author of the system of Quaternions and, with an air of careless insolence, he turned to his host and said: "Hamilton, I have been thinking of your Quaternions for the last few minutes, and there is nothing in it!"

"Excuse me, Sir George," Hamilton replied,

"I have been thinking over it attentively for the last twenty years, and there is a great deal in it."

Hamilton is now a shining light in mathematical history ; Airy is not widely remembered.

Enough has been said to carry the main suggestion that mathematics supplies no absolute certitude.

D'Alembert and Euler pointed out certain errors which a whole generation of mathematicians had been content to accept, and Gauss, who was the first great master of rigorous methods, in his turn pointed out various errors which both Euler and d'Alembert had admitted.

The question of certitude, however, goes much deeper than that of error or otherwise in the operation of a highly developed procedure. It arises in the elementary assumption of mathematics, even in the axioms. When studied by the light of a true psychology the question, for instance, of the truth of the axiom : "things which are equal to the same thing are equal to one another," has a different and far more interesting aspect than at first sight appears.

The assumption of the existence in themselves of a negative quantity or of the square root of negative quantities, conceptions which would have greatly shocked Apollonius, have been of great use in the development of mathematics, but I do not think

that their true meaning has ever been represented, even by the most brilliant mathematicians.

From the standpoint of my Psychology I say that the instinct of the Greeks was here correct. A negative number does not in itself exist at all. Number depends eventually on counting, and counting depends on the succession in time of certain phases, and it is a universal condition that these cannot move backwards. A minus number, therefore, should be regarded as the association of a number, therefore of course a positive number, with a certain mode of application or use in given circumstances. The square root of a minus number has no meaning as ordinarily employed, but a perfectly illuminated meaning can be obtained when the matter is regarded from this psychological standpoint, and properly worked out.[1]

The question of the square root of minus one, or, as it is called, the doctrine of imaginaries, has been discussed by a whole series of great mathematicians, and Cauchy and Hamilton, as well as Argand and Mourey, have written at some length on the subject, as have, indeed, many others.

I have not found the writings of any one of them convincing, not even Cauchy, who has the clearest

[1] These subtle matters arise quite naturally and become seen with perfect clearness when certain principles are grasped which I have discussed in *Principles of Psychology* under the title of "The Fundamental Processes of the Mind."

view of the effectiveness of the symbol and all it represents. Hamilton ostensibly built up his Quaternion system by consideration of this symbol, but the reasonings which he gives by way of introduction to his new treatise appear to me so faulty that I cannot but think he elaborated his system without regard to these reasonings, and then afterwards supplied them by way of logical completeness.

This, then, finally leads me to the question as to whether any great new discovery in mathematics would meet with a hostile reception or, what is worse, indifference at the present day. Mathematicians, of course, would deny the possibility, but they would have done so at every stage of the development of the science, such as we have noticed. Nevertheless, Cantor found a sort of inert resistance in calling attention to his "Mengenlehre," which supplied an instrument of great generality and power, and even now that his work has been taken up and developed in France and in England, for example by M. Emile Borel and Dr. W. H. Young, they have not secured for this subject the full recognition which it deserves. This is in part due to the great variety and extent of the field of mathematics itself, for it is only just to say that our Mathematical Society in London, under the impulsion of Professor Hardy and others, is working at a high level both of zeal and ability. The case is always more difficult, however, when new ideas

branch off at a deep level ; and yet I think that the future of mathematics will be found in researches of quite another character than those in which progress is being made.

I will, however, here give only the briefest indication. In reading the works of the great mathematicians one often sees that a result has been known to, or has been guessed by, the author, and that he has not reached it by the route of the difficult and tedious arguments which he inserts. What he has been doing there is to show, by the use of certain conventional instruments, a truth that he has arrived at by the exercise of other faculties. These " intuitions " have a real meaning and, in fact, as Gergonne remarked, we never properly grasp the full meaning of a mathematical demonstration until we gain something like an intuitive knowledge of the whole matter. These intuitions should themselves be the subject of research in order to find for them some ground of validity such, for example, as analogy with known forms, homogeneity, symmetry, or some suggestion of elegance in demonstration.

At a still lower level, however, mathematicians should go back to the deepest psychological foundation of their science, so as to gain a clear conception not only of the processes that are usually found to present some difficulty, such as imaginaries and infinities, but also to see clearly and fully the mean-

ing of the elementary processes of counting on which are based those of addition and multiplication ; with these in hand, and with certain space relations, the whole system of mathematics could be built up in such a manner that all of the processes might become as clearly visible to the mental eye as that of a carpenter in the workaday world, and yet so that the greatest precision could be obtained within the limits of that certitude which Nature herself has imposed in our mental operations. Mathematics becomes then a branch of psychology, or, at any rate, springs as all sciences do from that matrix. The study of mathematics will then become shown as a study of the theory of processes, and the whole body of mathematics would be the particular representation, in the concrete forms that we know already as mathematical expressions, of the play of these processes. The science will be formed on developable lines when these processes are well understood and properly defined, and related one to another on the basis of a principle of classification which will show in how far they cover the whole field.

Bring such an idea, however, to a mathematician, or lay it before the British Association. They will treat you with the lofty disdain that Apollonius might have showered on Descartes.

CHAPTER THREE

PHYSICS AND QUESTIONS OF RELATIVITY

RELATIVITY is one of the great intellectual fashions of the day, and when it was in its first bloom, after Einstein's visit to London, one might well appreciate how it posed a brilliant young man who could announce in a London drawing-room : "We have abolished Time and Space."

Truth to say, Relativity has turned the heads of more people than in his time Carlyle's vehement but obscure objurgations on things in general. Each, however, according to his fashion. The young man whom I have taken as a type is simply following the natural desire to "Épater la bourgeoisie" (to astonish his neighbours). Lord Haldane, as befits a statesman, talks on the matter in a more serious, or at least more solemn, way. His model is rather Polonius.

I mean nothing disrespectful to Polonius, for I spent some years in connection more or less close with many of that type and, at times—whether suffering from extreme mental lassitude, or believing, in an illusory fashion, that I could fit in with the conventions of contemporary society—I have,

when hearing Polonius described as a great statesman, nodded in vague appreciation.

But the word "convention" gives the clue to what I am driving at. Generations of works like that of Lord Haldane on Relativity might come and go with no advantage and no great harm to the community. Having caught at the word "Relativity," he applies it to all sorts of domains of life where, of course, it exists; but these exercises soon appear to be studies not in research of a science but in the ingenuity of the author in developing the materials at his command.

I remember the case of a friend of mine, a noted political economist, who lectured on what he called "The Two Irelands." He was in search of contrasts; there was the Ireland-this and the Ireland-that, and he began every paragraph of his lecture with the phrase: "There are two Irelands——." When he had reached the twenty-first of the series, he had so exasperated his audience that interruptions were on the point of breaking out. He continued solemnly: "There are two Irelands——"

"Then why the divil," cried a voice, "don't you go to the other?!"

It is here, however, necessary to put the matter in a more definite form. We are entering upon a chapter which demands close thought, while it serves as an introduction to arguments that touch

upon questions discussed all over the world to-day. We must therefore lay down certain criteria of judgment. The importance of a contribution to science should be judged by the manner in which it answers this question : Has it added a definite and necessary link to the chain along which science has been developed ?

Should the answer be in the affirmative, then a great work has been accomplished. If not, no matter how high be the reputation of the author, or how many columns of the newspapers he occupies, the work will be found, with the passage of years, to have slipped away from the ken of history. It may have been useful from an educational point of view but, without some sure criterion, we cannot tell whether, on the other hand, it may not have been an obstruction to real education by putting forward false views. That seems to me to be generally the case with our great popular teachers.

In Germany once, during my student days, I heard a Professor rehearsing the history of optics. Amongst those of note he mentioned Dollond, an optician in Cheapside who, though not a professed man of science in the academic sense, had improved the lenses of microscopes by removing diffraction. At the same time, the lecturer failed to mention names which were known the wide-world over ; even reputations such as those of Tyndall suffered greatly in this mode of examination because Tyndall

added nothing entirely original and important to the science of which he was a shining light.

On reflection I found that this mode of appreciation was entirely just, and it will be seen perhaps why, although I mention Lord Haldane's *Relativity*, I do not dwell upon it too seriously.

We now come to some very subtle notions, such as that of the Fourth Dimension, Curvature of Space and the non-Euclidian Geometry.

These are the remote sources from which Einstein's theory derives, and it is therefore necessary to gain some illumination in regard to them.

In tracing back the history of all these notions, one is led again and again to the German mathematician, Gauss, and I feel inclined to lift my cap every time that I come within the orbit of his influence. The theories, however, have been put forward less by Gauss himself than by his pupils, and I think that the notion of the curvature of space may be traced back to von Staudt, who has been already mentioned. From him it was taken up by Clifford, among others, in this country.

Clifford was an extraordinary fellow, and one who would have delighted the heart of d'Alembert in his search for mathematicians not afflicted with dryness of soul. Clifford had a freakish turn in his mind, and he was no doubt delighted to get hold of the notion that space was curved.

Imagine a straight line stretching on a plane

towards infinity in both directions. Now take a point as, for instance, on a paper before us, on which the line is represented. Then through this point draw another line which will cut the first. Then imagine that line as a sort of rod turning about the point as a pivot. As it rotates it still cuts the first line and, as we rotate it further the point of contact recedes out towards infinity. There will come a position in which the rotated line is parallel with the first. We should therefore naturally say that it does not then cut it at all; the language of mathematics is, however, conventional, and it is more convenient to suppose that the rotating line always cuts the first. We say that it cuts it at infinity. Books of mathematics contain many terms which seem in this way to run counter to common-sense, but they serve to keep a certain simplicity in the expression of mathematical formulæ. Thus, for instance, if a straight line is drawn through a circle, it cuts it in two points. If now keeping one of the points fixed, we rotate the line until it becomes tangent to the circle, we say that it meets it in two points which have coalesced. If the line does not come in contact with the circle at all, we still say that it cuts it in two points, though we cannot form the geometrical image to correspond.

Return, then, to our rotated line; we say that it cuts the first line at infinity; suppose, to the right.

But as the line is parallel to the first, then if we look to the left we see that it should also cut the line in that direction at infinity. We stop at nothing ; we accept that position and, as we have held all along, that the rotating line intersects the first at one point only, we say now that these two points at infinity are really only one.

But if a rotating line, moving to the right, comes into a position where it meets a point, that holds a like relation, to the left, the point itself must have moved round a curve, such as a circle. This suggests, therefore, that space is curved.

What it really means, however, is that we have adopted the conventional form of expression so as to maintain a certain uniformity in the manner of interpreting our algebraic symbols.

Let us come now to another paradox—that of the Fourth Dimension. We have already noticed the manner in which Descartes discovered his system of co-ordinates. It required three co-ordinates to define the position of a point in space. For a long time mathematicians were content with this, and three co-ordinates satisfied even our spiritual aspirations. But the world progresses, and the question was asked insistently : Why only three? . . . Lagrange supplied a fourth.

So far we have thought of figures in space without movement. But suppose that we were tracing out the movement of a particle in space, and defining

it by algebraic expressions, three co-ordinates would suffice if one moment were all ; but from one moment to another the body has changed its position and so we must introduce the element of time into our equations. Now the Cartesian co-ordinates were usually defined by the letters "x, y, z," and Lagrange indicated time by the letter "t," so that we now had "x, y, z, t." He did not call "t" a co-ordinate because that might have produced confusion with regard to the other co-ordinates, but he called them all "dimensions" ; so that, in this example, which has no esoteric mystery whatever, we were dealing with four dimensions ; but that which Lagrange saw so clearly, and expounded so simply, has helped to send many thinking men half crazy in their attempts to imagine a space of four dimensions in which the dimensions were all of the nature of Cartesian co-ordinates.

This is really the germ of the notion which has since been worked up with some elaboration. Before proceeding further, however, I wish to put forward a point which is more elusive than any we have hitherto dealt with, but of which the understanding is much more helpful.

What I say now is an abstract from the principles I have laid down in my *Principles of Psychology*, wherein I make it clear that space is one of the inevitable conditions under which we arise to consciousness at all, and the apprehension of space in

its elementary form is one of the Fundamental Processes of the Mind.

Space, in this view, as space, has no dimensions at all. Dimensions are produced only when we come to define the position of points, or to measure structures. Dimensions are, in fact, the marks both of our limitations and of our powers of description. One proof that may be given is that, before the day of Descartes, no one ever spoke of four dimensions or of three dimensions. The reason why we are brought back so insistently to three dimensions is to be sought in a deep analysis of the whole conditions of our physical and mental constitution. A star-fish, for example, endowed with the wisdom of Descartes, might have taken five as a basic number for its co-ordinates.

But further than that, Plücker, in his desire to escape from what was merely arbitrary in the system of Descartes, has given us a geometry in which space is defined on a basis of four co-ordinates, though it is true, in defining them, he goes back to the Cartesian system. Naturally, our equations would, with Descartes, exhibit this space with "x, y, z," as far as his co-ordinates were concerned; but algebra has a life and development quite apart from geometrical applications, and Sophus Lie and Riemann before him talked of space of "n" dimensions, where "n" might be any number. That simply meant that they had extended the use

of symbols from "x, y, z" to x_1, x_2, x_3, x_4, x_5,—and so on. Then they and others sought, subsequently, to interpret these equations in graphic forms as, for instance, by finding geometric figures if possible that corresponded to them. It is in the search for such representation, arising from the desire to give greater generality to algebraic expressions, that we have come across some remarkable forms of thought which, at length, stimulated the mind of Einstein.

We have now reached a point when we are far beyond the space of fourth dimensions. We can cheerfully enjoy the space of a dozen dimensions, and we have the choice also of hyperbolic space and of elliptic space, as well as of the space with which we are more familiar.

What is the meaning of these extraordinary terms? Certainly nothing that really disturbs our own space, not even by the merest ripple of ether. The French mathematicians have, in particular, been insistent upon that point, for clarity of thought and expression are stamped on French genius. But neither Gauss nor Riemann, nor the great Norwegian Sophus Lie had any confusion with regard to space of "n" dimensions.

These spaces may be regarded simply as representations, even if not tangible and graphic, of algebraic expressions involving several variables. Riemann, in a remarkable Memoir which he com-

posed as a young man, has entered profoundly into this question, and he has shown a form of expression depending on a certain parameter, that is to say, a variable quantity, not necessarily one of the co-ordinates, x, y, z. When the value zero is given to this parameter we arrive at conditions of space as ordinarily understood.

When other values are given we arrive at relations which remain true, and the next step is therefore either to imagine some space to which they refer, or, in default, even of imagination, to hit upon some feature of the expression which suggests analogy with geometric forms. Hence, Riemann has his elliptic space and Bolyai his hyperbolic space.

The mention of Bolyai introduces another topic connected with the last, which is famous under the name of the non-Euclidian Geometry. Though the name has become familiar far outside scientific circles, the general impression is that we are here dealing with matters of a somewhat dangerous wizardry, and that magicians are either men of extraordinarily subtle brain-power, or else sheer lunatics ; but in neither case fit to be trusted with the affairs of such a well-ordered, conservative institution as our space.

This reminds me of a little anecdote of Rodin, who was once at the table of a man who certainly had some filaments of genius, though in too streaky a form, and who was in the habit of reflecting on

such aphorisms as that of Archimedes, who said: Give me a fulcrum and I will move the world. On this occasion at luncheon the host waked up from profound reflection and, with a far-off look in his eyes, muttered: "I could stop the world." His son, not doubting him, put his hand quietly on his father's arm and said: "Don't, Papa!"

That is how most of us have felt about the non-Euclidians. The two most famous are Lobatschevski, a Russian who was a professor of mathematics at the University of Kazan; and John Bolyai, a Hungarian, son of Wolfgang Bolyai, who was a particular friend of Gauss. John, this mysterious wizard of the non-Euclidian geometry, was still a young man about town when he published his famous researches. He was so mundane as to be an accomplished fencer, and perhaps the only indication of unusual or malign endowment was the fact that on one side of his head the hair was white, on the other black. A materialist doctor, however, said that was due to migraine.

It is difficult to give in a brief space a clear idea of what Bolyai and Lobatschevski were driving at, but I will try to offer a useful suggestion. People were content to take the axioms and postulates of Euclid at their face value, but, as the minds of mathematicians became developed in analytical power, they began to ask: Has Euclid a right to make these assumptions without further explana-

tion? Do they rest simply on experience or are they inevitable in the nature of things, and is that inevitability susceptible of being shown?

One axiom in particular occupied the mind of Gauss, off and on, for forty years. This is the doctrine of parallels. One form in which it may be expressed is this: If two straight lines be parallel and if they be cut by a third straight line then the interior angles formed by this straight line with the two others are together equal to two right angles. This statement is closely connected with another, which is elevated to the rank of a proposition: that the three angles of a plain triangle are together equal to two right angles.

Most of us have been content to accept these propositions, but Gauss actually took the trouble of measuring the angles of a huge triangle formed by two mountain-peaks from the point on which he was stationed. He found within the limits of error a concordance with the theory. That is, indeed, what he had expected; but the uncertainty in his mind gradually acquired a form which might be thus expressed: Is it possible to build up a system of geometry in which the so-called axiom of the parallels does not hold? He concluded that it was, and his suggestions were afterwards developed by Bolyai and Lobatschevski.

Certain of the ideas which they utilized may be thus expressed: Take a sphere of any kind and

draw round it a great circle as equator, and mark two points as poles. From one of these points as a pole draw two great circles. Now these two great circles will meet the equator perpendicularly, so that the circular triangle formed in this way by the equator and the two other great circles will have more than two right angles, for there is the angle formed at the pole to be taken into account also.

Yes, but the reply will come, that has necessitated a spherical triangle. The next suggestion is this : Imagine a circle with a tangent, lying horizontally, for instance, and stretching towards infinity both ways. Now, while keeping the point of contact fixed, imagine the radius of a circle to enlarge progressively. The circles successively formed will of course have one point in common, but in the rest of their course they will come progressively nearer to the tangent. If this process be carried out to the limit, the circumference of the circle may be taken to be coincident with the straight line—or, at least, that is the usual form of expression accepted by mathematicians. Similarly with the sphere. If the radius of the sphere be indefinitely enlarged, any portion of the surface will approach nearer and nearer to the form of the plane.

It is on lines of this kind that Bolyai and Lobatschevski both worked. And they succeeded in this far, that they set forth mathematical forms, on the basis of which they worked out consistently all

the transformations they required ; these forms being such that, when a certain determination was given to one of the variable quantities, the equations and the transformations became those of our usual Euclidian geometry.

The expression of fourth dimension, as we know it now, was due to an Italian mathematician, Beltrami, who imagined a being first of all with a sense of only one dimension. That being might creep along the circular lines of a spherical triangle without observing that it was not on a plane figure ; then he endowed his being with a sense of two dimensions, so that it could crawl along a plane and recognize areas, but so far without any sense of solidity. He then endowed it with a sense of three dimensions and brought it, so to speak, into our company.

But almost inevitably such promoted intelligence would ask : How about the next dimension ?

It does not follow that there is a next ; in fact, to come back to a statement I have already made and on which I must insist to secure full acceptance, I say that in space as space there are no dimensions at all ; dimensions have reference only to the instruments, although these may be subtle and intellectual, by which we measure space. Having got that far we can, out of the formless space, carve, so to speak, any space we require, whether our plane Euclidian space, or curved space, or Bolyai's hyperbolic space, or Riemann's and Beltrami's elliptic space ; and

if we are at times unable to form a visibly clear conception of these spaces, that need not trouble us, for we can take the name of space itself as simply a conventional name by which we refer to the collocation of our mathematical symbols.

Another question, however, may well be asked : Is there nothing more than mere effort of wit in all these elucubrations ? And has the matter any importance at all ? I think it has, for it indicates to us a way of looking at our mathematical processes from a height, so that what we have been accustomed to recognize as the be-all and end-all of their expressions becomes contained in something more general, of which they form a particular case. In this way the mathematical instrument, as well as the powers of our mind, becomes developed. Thus, for instance, at one time, mathematicians were content to investigate the properties of the circle. It was something of a leap to proceed from that to the ellipse ; and something else was added when it was recognized that the circle was only a particular case of the ellipse.

It was a still higher flight when all the conic sections were included in the survey, and the theory reached great completeness when it was seen how any one of the conic sections might be progressively transformed so as to develop into any one of the others.

I will not pursue this question further, however

interesting it may be, because it will lead too far ; but it is worth while mentioning that Gauss, though well on in years at the time, and continually occupied with very important work, was so desirous of learning of all that Lobatschevski was writing, that he took the trouble to learn the Russian language so as to read some of his writings that had not been translated.

CHAPTER FOUR

THE ORIGINS OF RELATIVITY

IN these days when Relativity has passed into the language as a sort of philosophic slang, it is worth while remembering that the opposite pole was once equally fashionable—the Absolute !

The Absolute was no light matter. It occupied men's thoughts to such an extent that, strange as it may now seem, a hard-headed banker in Paris was induced to part with a sum of one hundred thousand francs to a clever Polish mathematician, Wronski, by name, I believe, who promised to reveal to him the secret of the Absolute. The case is known because the banker afterwards became discontented with the Absolute, or at any rate with such portions of it as Wronski was able to deliver. The Absolute dominated the Dark Ages, and it was the Prince of Denmark to the work of Plotinus, to whom Dean Inge has given special attention.

The modern form of the notion really derives from Kant, or at least it was he who gave vogue to this and many other ideas in which we have a right to be interested, for they have addled the brains of many generations of promising youths who have

brought great intelligence to the Universities, and in this sphere apparently lost them.

This Absolute of Kant's factory has yet curiously enough prepared the way for the modern vogue of its rival, Relativity.

Kant believed in absolute space, but Goethe and Gauss, who met from time to time, were inclined to be critical of the little Königsberger's conclusions, even the most solemn. Gauss was unable to form a clear idea of what the Absolute meant, and he was indeed led from these considerations to a train of thought which induced him to question Euclid's axiom of parallels.

But every self-respecting German still considers that his education is incomplete unless he can quote Kant's *Critique of Pure Reason*, and if he be a specialist, the little tincture of philosophy so implied rounds off his knowledge and gives him what is called culture.

Certainly one would not speak ill of Philosophy, if the philosophy be genuine ; but Kant is used nowadays less to illuminate a way of thought than as a missile, hurled *ex cathedra* at recalcitrant minds, in order to put an end to further reasoning. There are a few authorities who have been thus employed from age to age. In the Dark Ages it was, as we have seen, Aristotle. Now it is Kant, or, possibly, Bacon. It is well to enter a little into this matter because we will find instances recurring, not now

and again, but in a thousand ways and in many spheres, of intellectual interest.

Once when sitting reading in the Library of the House of Commons I saw a Great Statesman enter. I confess even that astonished me, because it was the first time I had ever seen him there and, as a matter of fact, I had never once seen a member of Parliament take down a book of any kind to give it serious study. The Great Statesman went tapping along the backs of the books on a certain shelf till he came to a volume which he took down, and searched through for some time, until he lit upon a passage which he carefully copied. The book was one of Bacon's, and a couple of days afterwards I heard the Great Statesman throw this passage at the heads of the House as a final and convincing argument. Bacon had certainly not written with the particular question in view of which the Great Statesman was speaking, and he himself had not studied Bacon in the sense of seeing through his philosophy as a body of thought, resting on certain foundations. Bacon was simply a big name to throw into the debate.

Karl Marx mentions something of the same in his celebrated book on Capital, or is it in one of his minor writings? He says that many authors give themselves an outside decoration of philosophy which, however, does not enter into their arguments at all. He himself is an example in point. On the

philosophical side he depends on Hegel, who, again, remounts to Kant—always that malign influence—but the philosophy of Hegel has no organic connection whatever with Karl Marx's exposition of economic principles.

All this has really a bearing on Einstein and Relativity, for we will have a much clearer view of the meaning and importance of his doctrine if we trace it to its sources.

We have seen how Bolyai and Lobatschevski desired to attain a geometry more general than that of Euclid, and we have seen how Riemann and others sought for a space more comprehensive than that of our natural space ; and Einstein really derives in part from these ideas. He has asked himself the question : Is it not possible also in the domain of physics to obtain expressions more general than those which contented Galileo and Newton ? This was a very suggestive question, and it is extraordinarily interesting to trace out its consequences ; but we must, from the outset and all along, have clearly in mind the nature of such a question, and we must remember what has been already said regarding the disturbance of space by the non-Euclidians ; or, to put it in another way, we should remember, for it would save us from abundant nonsense.

When Einstein arrived in London and delivered the celebrated address at King's College, it was

especially interesting to me, and not merely on the score of physical theories ; it made a study in human nature. The hall was well filled, and the intellectual *élite* of London was there, and the stage-managers had impressed a sort of religious atmosphere upon the scene. One could hear a pin drop before Einstein rose, and there was on his auditors that expression which comes to all of us when we feel that we are superior and good and exclusive. Einstein spoke in German ; only a small proportion of the audience understood him ; of those who knew the language, only a small percentage again were students of mathematical physics. Finally, those who followed so far, were few of them versed in German metaphysics; and yet Einstein gave us a discourse compounded of all these ingredients.

I do not mean to say that this lecture was wasted, for a distinguished medical man came to me afterwards and, with an air of authority, said : "A most admirable address ! And yet I won't commit myself. There were parts of his explanation, don't you know, which did not quite satisfy me so much as other parts" ; and with these words he glared at me through his pince-nez as much as to say : Now contest if you can that I am a Super-Man in the realm of science !

On the contrary, I felt inclined to doff my cap, for the whole show seemed to me in any case to have achieved one of its objects, which was to give

an enhanced value to the tentative reputations of some of the leading lights who graced Einstein's platform. I do not say this in cynicism at all ; it is my considered opinion that, during the actual lifetime of a scientist of original power, especially if he trench upon matters of controversy, his reputation is determined by all sorts of questions of authority, and especially of conformity to prevailing religious and political tenets. These should have nothing whatever to do with the matter, but a test of the influence of politics, for example, was found during the War.

Previously to that, and particularly at the time when the fashionable world indulged in righteous ecstasies over the exploits of the "hero-souled" William I in 1870, there was a wave of pro-German enthusiasm in this country, and it was fostered by the various arts of sycophancy and misrepresentation which have an active life even in scientific circles. The cult of Germanism had spread so far that it was taken up even in some quarters in France. A French anthropologist, Gobineau, had put forward a theory couched in the pompous terms of science, and apparently therefore having the support of scientific reasoning, but really consisting of a farrago of assumptions loosely strung together on insecure data, and of which the conclusion pointed to the Germans as a race of superior beings destined to rule the world. M. Gobineau's reputation mounted accordingly.

During the War these same Germans were described as the scum of the earth, the manifesto of their great super-men was regarded as a document which indicated the degree of abasement of which the human mind was capable, and I heard members of Parliament, such as those sent in by Universities, belittling all German science in terms which, in proportion to the ignorance they displayed, secured the acclamation of the speaker.

Einstein's own popularity was due in part to the fact that though steeped in German culture, he was not of German nationality, and he had refused to endorse the manifesto of his German colleagues. To my mind there is something pitiful in estimating science by the standard of fourth-form jingoism.

Science, if it means anything at all, beyond procuring us material comforts and serving the sensual side of our nature, has a great spiritual value, not in the sense of bolstering up our old prejudices or absurd ideas, but as gradually unfolding to our vision the structure of the world, visible or invisible, in which our lives are played out and which, in wonderful ways, determine our actions.

To return to Einstein. He is, in the first place, a physicist. It is a great thing towards understanding a man to find clearly what is his *forte* or, again, what the Germans would call his *Ausgangspunkt*. We have seen how that helped us in regard to Aristotle, and in tracing out the develop-

ment of such a universal genius as Leonardo da Vinci, we find all brought to a sort of unity if we regard him primarily as a mechanical engineer. But Einstein as a physicist has been attracted to the theories of the non-Euclidians and to the wider researches of Riemann.

There is one point in his conclusions which has a mysterious air until it is examined, but which is taken directly from Riemann ; it is to the effect that the world may be unlimited and yet not infinite. I can imagine nothing more calculated to stir the soul of thought-centres in Suburbia than such a doctrine ; or anything more likely to set one on a pedestal of malign prestige. Imagine, for instance, a young disciple of Einstein informing an afternoon-tea circle with a Dowager Duchess in the company, that we have found the world to be illimitable but bounded !

What Riemann meant by this may be explained by a simple example. If Beltrami's two-dimensioned insect were to crawl over the surface of a globe, he would never meet any limit to his progression, but his little world would be bounded all the same.

The discourse of Einstein was really divided into three parts. The first gave us the Galilean or Newtonian relativity, without which of course it would be impossible to describe physical phenomena ; the second part gave us Einstein's suggested explanations of certain physical occurrences, such as

of gravitation. These were artificial and tentative, seeming almost to demand the term which we have been forced already to use, *ad hoc.* The third part dealt with his divinations in the realm of metaphysics. These smacked inevitably of Kant.

There is a tradition amongst German scientists that an exposition of theory is incomplete without a reference to Kant, however vague, for that touch indicates a certain enlargement, a capacity for flight that lifts one above the dull earth of reasoning. Our own distinguished Presidents of the British Association seem rather committed to Shakespeare, or Wordsworth, or at least one of the safe and, where possible, archaic poets. The quotations hardly ever arise from the nature of the address. They have the air of being sought for first by the help of a concordance; and so with Einstein's metaphysics.

In his more serious work, Einstein has wrapped his theory about in mathematic form, but with the suggestion already given in regard to Bolyai and Lobatschevski, it may be recognized that these mathematical expressions were not originally suggested by the study of phenomena to which it was desired to give precise expression; rather the mathematics come first as an extension or generalization of the Galilean or Newtonian forms, and then phenomena, or modes of representing phenomena, are sought to correspond with the mathematics.

The essence of the whole business may be fairly well represented by one example, with the same proviso as we have already made, that this is not the condensed expression of the whole theory, but an indication of the manner in which the suggestions have arisen ; it represents the germinal idea.

Einstein says that if we are studying certain phenomena passing at a distance, and if we have a distant clock to record the time, and a clock exactly similar near by, then the distant clock gives us a fallacious indication of the time, because its message is borne to us by the undulations of ether like those which correspond to our means of perceiving the phenomena themselves. Thus, for example, if something happened when the hands of the distant clock there stood at twelve exactly, then since the vision of the phenomena would not come to us until the ethereal undulations had traversed the intervening space, we would not thereupon see the hands of the near clock in the position they occupied at the moment of occurrence of the phenomena ; so that we would not have perception of the phenomena as they existed at the moment that our vision was stimulated. Suppose, however, that, in quite another instance, we wished to time some occurrence which gave us an auditory signal, such as the report of a gun ; and suppose, further, that we had already ascertained by independent means the speed of propagation of sound waves, and that we could accept the time of

transmission of the visual signal as being negligible; then, noting the point of time of arrival of the sound signal, we could ascertain the distance of the source of the sound.

Returning again to the original example, we might have already ascertained, as in fact we have, the velocity of light. We might also by trigonometrical means, ascertain the distance of the object. Knowing therefore the distance of the object and the length of time required for a light signal to come, we would know at what length of time previous to our reception of the signal the event actually occurred.

Here we are supposed to be dealing with real clocks, or the fictive representation of real clocks, and part of the paradoxical form of Einstein's statement arises from the confusion between what is real or representable, and what are abstractions. Thus, for instance, although Euclid speaks of a line as length without breadth, it is not possible to represent a line without breadth; but what Euclid really requires from us is that when we take real or representable lines into consideration, we should disregard the associations arising from their breadth. That process of abstraction is feasible and indeed familiar.

Proceed a little further, and consider Newton's laws of motion; he starts with a body that is supposed to be at rest, but no body is ever at rest.

He introduces the notion of force, but what force is, we do not know and, as we have seen, great physicists have wished to eliminate the notion altogether. Newton speaks of bodies continuing for ever in a straight line unless acted upon by new forces, but what is "ever"? It cannot be a matter of experience, and no one can ever form a true conception of what it means. Do we say therefore that Newton's Laws are useless? No,—on the contrary, they are extremely valuable for, on the basis of these limited conditions, we can estimate the action of new conditions successively introduced. So it happens that even if we had been unable to measure the velocity of light—and that measurement is only provisional—we still would have been able to imagine the possibility of such a measurement, and therefore to have interpreted these elementary forms of Einstein's new Relativity on the basis of the old. There is, in fact, nothing gained in this particular regard by the introduction of these new conceptions.

The question of physical interpretation rests on different ground altogether, and has to do with the special doctrine of Relativity no more than the hypotheses of men like Fresnel and Clerk Maxwell, who had never been troubled by the new Relativity at all.

Thus again, let us go back to the non-Euclidian geometry, and refer to the actual observation of Gauss in measuring the three angles of a very large

triangle. Suppose that Gauss had found that the sum of those three angles differed from two right angles,—would he have been justified in saying that space had a hyperbolic form, or the elliptic form, corresponding? No; the result might have been due to some physical conditions which had nothing whatever to do with these theories. Imagine, for example, a large sphere with two points taken on the equator so as, with the poles, to form a spherical triangle. Let the supposition next be that light travels by circular arcs such as those of this sphere. Gauss's experiment carried out by someone on this sphere would then have shown the angles of the triangle greater than two right angles, but the result would have been due, not to any peculiarity of space in itself, but to the mode of propagation of light, about which the mere transformation of mathematic forms can teach us nothing.

These forms of space do not exist in themselves as necessary attributes of space. If, for instance, we could conceive space as "hyperbolic space" then, since we have arrived at the notion of hyperbolic space by starting from Euclidian space and modifying our formulæ, it is evident that from hyperbolic space we could, by a reverse process, arrive at Euclidian space, and so build up the system of geometry that we know. We can map out, in concept at least, the various forms contained in space, though space, as space, is restricted to none of these forms.

Let us, however, now follow Einstein or his pupils into some of their conclusions. He explains the mechanism of gravitation, though his suggestions here are merely tentative and artificial, and unsupported by any kind of evidence that they represent the reality. Clerk Maxwell before him gave us mechanical representations of strains in the ether corresponding to electro-magnetic phenomena; but these, again, were vague. In all such cases the effort is made to explain something that is at present very mysterious and recondite in terms of the few principles with which we have become already acquainted; but this restricts too much our resources of invention. How could anyone without experience have guessed at the phenomena of induction, for example?

However, we may leave this particular matter there for the present. Einstein has simply done what scores of physicists are doing all over the world; that is to say, he has sought for what are called explanations, by reducing phenomena to others which, it is true, we may not be able to explain, but which have become accepted as familiar.

Another of the results of the Einstein school is that the ether itself may be dispensed with, though the great bulk of physical science has been built up on the assumption of the existence of an ether which produces the undulations of light or of electricity, and of all those discovered in recent times

which fill up the gaps between these undulations and extend on either side.

It must be confessed that the orthodox physicists who cling to ether give us very contradictory accounts of it. I gain from a reading of a distinguished French writer, M. Houllevigue, who cites M. Brillouin, that a gramme of ether would fill a cubic kilometre ; but Lord Kelvin described the ether as being something like a jelly—something solid, in fact, or something in a state resembling solidity.

Then, in order to account for certain phenomena of light, according to the electro-magnetic theory, Kelvin, Fitzgerald, Hicks and others have calculated that the density of the ether need not be many times greater than that of platinum ! Larmor gives it a rigidity greater than that of steel ; and Karl Pearson surmises that the secret of energy itself may be found in a sort of strain, or deformation of the ether.

Now all this seems to be too great a " strain " to put upon such a delicate substance as that which weighs only a gramme to the kilometre cube ; or which, alternatively, as they say in the world of law, does not exist at all.

All these theories cannot be correct ; is it possible that these distinguished authorities are capable of talking nonsense ? I am forced to the conclusion, fortified, moreover, by a review of the whole history

of science, that it is possible. Jacobi, the mathematician, once remarked that there were two kinds of mathematical expositions liable to error : Those that were so short that no conclusion emanated from them, and those that were so complex and long that before the conclusion was reached, the truth may have escaped by the way.

When, therefore, these great authorities reach such a result as that the ether must be much denser and more rigid than platinum, the conclusion that seems most feasible is, not that such a determination should be accepted, but that it should throw grave doubt upon the value of the conceptions, and the arguments they have used. That is a practical principle which it is necessary to apply again and again.

The ether of which the Einsteinians deny the existence has lately been the subject of measurements by some of the American school, notably D. C. Miller, who has even calculated the viscosity of the ether.

Sir Oliver Lodge accepts the ether, and he even imagines a certain structure for it in order to allow solid bodies to pass freely through it. He says that these solid bodies are ultimately formed of molecules with relatively considerable spaces between them, and it is in these interstices that the ether passes. I confess I am unable to form any conception of a structure that would enable solid bodies to pass through in the manner in which he

describes for, though one layer of the solid might have an open-work form, yet the molecules are not placed symmetrically in succeeding layers, and there is no clear passage for particles however small.

But Sir Oliver accepts the Einsteinian theory and, in order to account for certain phenomena, he says also that a body passing through ether at a high speed, becomes shortened by reason of that fact alone. This was the suggestion first made by Fitzgerald, of Dublin, in conversation with Sir Oliver, and Sir Oliver immediately saw the truth of it.

Professor L. Silberstein, a noted physicist of Polish origin, who has written, among other lucidly conceived works, a good book upon Relativity, congratulates Sir Oliver upon being able to see scientific truths so readily, and on such exiguous grounds. Really, it seems to be a perfect specimen of the *ad hoc* hypothesis, of which we have already made examples, and of which the supply will always keep pace with the demand.

All this would be well, perhaps, were it not for the previous supposition—that a solid body moves in the ether as if the fibres of the ether passed through its interstices without shock, but in that case it seems difficult to account for Sir Oliver's hypothetical shortening.

All these elucubrations have come to light in the efforts to explain a celebrated experiment conducted in the first instance by two American observers,

Michelson and Morley. They reasoned in this way: If the earth were moving in the direction of a ray of light, then the velocity of light should appear greater than when the light was transmitted in a direction at right angles to that of the earth's motion. They found, however, no results which within limits of observation pointed to any difference of time.

Now suppose that there had been no movement at all of the earth in regard to the source of light, there would be no difficulty in supposing that the beam would take the same time travelling equal distances in directions at right angles to the earth, but these conditions could be virtually realized if the ether itself were carried, within the compass of the experiment, along with the room and the apparatus and the observers. There would still be no difference of time discernible, if the ether, without being immobile in regard to these objects, were yet possessed of a viscosity such that for near objects the effect was, within the limits of observational errors, like that previously supposed.

This was, in fact, the explanation which, by anticipation and for another reason, had been given by Fresnel. It is the explanation of the ether drift. The explanation may finally be proved not to hold but, as a tentative hypothesis, it seems to have many points of advantage over Sir Oliver Lodge's suppositions, which really are no explanations at all.

Another of Einstein's conclusions is that the velocity of light represents the maximum of velocity in the universe. His whole theory is built upon the supposition, right, no doubt, that all movements are relative ; the velocity of light, therefore, must vary according to the relative motion of the source and the goal ; and this statement of plain fact is not invalidated by the observation that the velocity of light is independent of the velocity of the source of light. To make this clear it is only necessary to suppose that the ether responds immediately to stimulus.

But quite apart from all this, how does Einstein feel sure that he has discovered even all the physical agencies which can communicate signals ? It is only recently that we have known anything of wireless waves ; who could have declared beforehand, without observation or experiment, that the velocity of propagation of these waves was the same as that of light ? But even in the scale of undulations there are waves still to discover.

One of the latest investigations of Professor Millikan has been in regard to waves of a length many times smaller than those of X-rays, and of which the origin appears to be extra-terrestrial or "cosmic" ; as it is only recently that we have made acquaintance of these waves, how can it be affirmed without investigation they have the same rate of propagation as the waves of light ?

Here, then, we are face to face with assumptions which are either unwarranted or which, if they prove according to a certain theory that the velocity of light inevitably represents a maximum in Nature, should make us rather reconsider the basis of the theory and the course of arguments leading to that inacceptable conclusion. Nature is not inconsistent ; it is only our faulty explanations that present paradoxes.

What I have been seeking to do is to carry out a sort of dissection which, while laying bare all that is consecutive and coherent in Einstein's doctrine, yet removes whatever is in the nature of mere accretion or ornament to that theory, or accidentally connected with it.

I eliminate altogether the metaphysical side, for any theory that leads to confusion of space and time is absurd, if we may use this term as Euclid did of old to warn us to retrace our steps.

The physical hypotheses are tentative ; they arise by way of explanation, all of the *ad hoc* character, of observed phenomena. This statement is not infirmed by the fact that certain astronomical observations seem to verify some of Einstein's conclusions ; for instance, that waves of light become deflected when passing near a vast attractive body, such as the sun. That is an hypothesis that might stand on its own basis, but it has nothing specially to do with Relativity.

What then remains? An extension, or generalisation, after the manner of Lobatschevski, of mathematical formulæ, employed especially in physics in accordance with certain conceptions but which are capable by means of generalization of being made applicable to other conceptions.

What Einstein has done is the work of combining together an array of different notions, capable of division into three main parts; and he then speaks of these as if they were all co-ordinated and held necessarily together under a principle which he calls the special Relativity. That term, however, is inapplicable.

Henri Poincaré, who contested Einstein's theories, was certainly not inferior to the Swiss physicist in subtlety of conception; he put forward the proposition with which I propose to close this discussion on Relativity.

He said that it was equally true to affirm that the sun revolved round the earth as to express it that the earth revolved round the sun. When I first read this, I confess that I took it as an example of the epigrammatic style of the French, saying something not quite accurate, in order to induce attention to a certain point of view. But on looking into the matter, I found it to be a definite statement of fact.

Suppose that we were placed in the centre of a fountain throwing off sprays of water in symmetrical forms with regard to our position, we would be

able to describe the main appearance on fairly simple terms ; but suppose that we afterwards shifted our position ? Then the movements of the water would seem not only unsymmetrical but complex to a hopeless degree.

Now when we conceive of the sun—or rather, the centre of gravity of the solar system—as the centre about which the earth and the planets revolve, we get fairly simple expressions in mathematical language.

But if we take the geo-centric position, that is to say, look at the occurrences from the point of view of the earth, the actual movements are unaltered ; the sun really does revolve round the earth ; but the mathematical expression of all this, and the conception we form of the movements, becomes much more difficult to express.

The advantage therefore of these discussions on Relativity would be found in giving a greater freedom and scope to our conceptons and to our mathematical expressions, so that what we have been accustomed to observe as if it were something of an absolute character, would seem to be a particular case of more general possible forms. Meanwhile the Universe will move as before, time and space will not become identical, and the ether, whether viscous, non-existent, or solid—for distinguished authorities give us a full choice—will not compress bodies over which it glides without resistance, simply to get Sir Oliver Lodge out of a tangle.

CHAPTER FIVE

DOGMAS OF SCIENCE—PHYSICS

CARNOT'S Heat engine has been the delight of professors and the bugbear of students for a hundred years. The students have seldom caught the real meaning of the exposition, and circumstances have lately brought me to believe that this is also the case with the professors. Had I been a classical writer according to the academic model, I would not have spoken in a casual manner of Carnot's engine, I would have ushered in the chapter in a phrase of this kind which I take literally from a famous French philosopher :

"According to the profound formula of M. Bergson, the great discoveries are often made by the sounding-lead dropped into pure duration. The master-feat of the sound, the definitive discovery, is the principle of Carnot, because it renders precise that which forms the fund of our conception of the world of sense, while we perceive only obscurely, however, the notions of Time, of Change and Irreversibility."

This is very beautiful. I give it as a gem of Schoolmen literature ; it has all the elements : the pomposity, the appeal to authority in the name of Bergson, and the air of profundity which cannot have escaped the reader. There is only one diffi-

culty and that, I confess, is in my own poor mind. I did not know what it meant when I first read it, and though I have returned to it again and again I still do not know.

Carnot himself never wrote nor thought in terms such as these. He was prompted at first to his researches by perfectly practical motives. The steam-engine had not long been invented. Various other machines had either been realized or proposed; and in particular, a suggestion had arisen that the efficiency of machines could be greatly increased if ether, or alcohol vapour, were used instead of steam.

Carnot, then a young officer of artillery in the French Army, nephew of the famous Lazare Carnot, turned his attention to this matter and brought to bear upon it one of the finest intellects known in the realm of science. Although his ultimate aim was practical, he followed the models indicated by Galileo and Newton, and conceived ideal conditions under which a heat engine might work.

In order to make subsequent remarks intelligible, it is well to give a brief indication of his system, and it is necessary to make use of certain technical terms. Isothermal lines may be taken as lines plotted on a plane surface in which the vertical co-ordinate is measured in pressures, and the horizontal in volumes, the isothermals being such that the curved line indicates the pressure corresponding to a certain volume when the expansion has taken place

at a constant temperature. Adiabatic lines represent the position of affairs when the expansion has taken place in such a way that no heat is introduced from outside into the system during the process. During the expansion, therefore, there is a cooling.

Suppose then, that we have an air-engine, with the air at a certain temperature and pressure, and that we allow the piston to move accordingly in expansion, while keeping the engine in communication with the source of heat, so that the constant temperature will be preserved. We represent the relations of pressure and volume on our isothermal curve, which will be nearer to the horizontal than to the vertical. We then take the machine away from the source of heat, and allow the expansion to continue, but now adiabatically. We represent that on our plan by an adiabatic curve, which is nearer to the vertical than the isothermal curve. The air will now have been cooled to a lower temperature, and we now bring our machine in communication with the condenser, or sink. We then compress the air isothermally, but of course at this lower temperature. Then, at a certain point, we bring the machine back to its original position by an adiabatic compression.

The figure presented on the plan will be roughly that of a parallelogram, and the area of the parallelogram gives a measure of the amount of work done in the process at the expense of a certain quantity of heat.

Carnot held that his ideal heat engine represented the highest degree of efficiency attainable and, with a few cavillings here and there, this position has been accepted ever since in the schools where the science of thermo-dynamics is taught.

It must not be supposed that Carnot's researches, although this theoretic work was supplemented by a great number of excellent experiments, were received with enthusiasm. He died young, and his work was little known during his lifetime, and in a noted French book of reference which I consulted once to verify a date, I found that the name of Sadi Carnot was missing, although the book dilated on the political doings of many of his relatives ; and yet, be it lunacy to say so, I think his work is greater than if he had deluged Europe in blood or given to the world crude laws representing a low mental and moral outlook.

Although Carnot's work attracted so little attention in his own day, it has since been the subject of innumerable studies and articles, and is at the present time being discussed more keenly than ever. This is indeed the main reason why I have introduced it now, for space does not permit fully to enter into all the points of theory involved. Only recently I read an article of Dr. J. S. Haldane, which was one of the most stimulating to thought that I have seen and which, moreover, had a practical tendency in the sense of indicating the utilization in the most efficient way of the steam-engine.

In this paper, read before the Institution of Mining Engineers on 16th June, 1925, Dr. Haldane says that, so far from Carnot's cycle representing the highest degrëe of efficiency, it is " radically inefficient." He points out that Carnot had furnished a criterion by which we could judge of the efficiency of heat engines, but he argues that he failed in applying that criterion correctly. " His unsuccessful attempt was, however, a great one, since it has continued to mislead scientific men and confuse engineers, for now more than a century."

Haldane's criticisms appear to me to be justified, and he has shown how a greater degree of efficiency may be obtained by making the first expansion entirely adiabatic.

What I especially admire in his memoir is perhaps not even the scientific acumen, but the audacity of the man who can turn to the congregated forces of the University, these high Principalities and Powers which give the law to the world, and tell them they are mistaken. When I come to think of it, it is remarkable, too, that I should think of extolling this quality for, in a sane and honest man, courage ought to be there, like Teufelsdröckh's learning, naturally and of course ; but I regret to say —and here is the one damning disproof of the assertion that science affords a sufficient culture—that I have found an extraordinary lack of courage amongst some of the great intellectual lights ; so much so,

indeed, that moral cowardice has been petted and decorated and treated as a high form of virtue.

A thousand points arise out of Carnot's work, and I am reluctant to leave him. For one thing, he not only improved the engines of his own time, but he influenced long afterwards the researches of Diesel who designed his highly efficient engines after careful study of Carnot's isothermal and adiabatic lines. Yet there was more than one point of theory in which Carnot now appears to us as faulty. In his day the caloric theory prevailed. No one knew precisely what "caloric" was, but it was supposed to be something material, the amount of which changed according as bodies were heated or cooled. Lavoisier himself was apparently content with the caloric theory, but Rumford and Davy entertained grave doubts as to its reality. Rumford had his attention called to the fact that in the process of boring cannon the chips thrown off were greatly heated, and the greater the energy with which the work was performed, the greater was the heat. He thought that this was inconsistent with the idea that caloric was a substance, though other great physicists, including Cavendish, had tided over such difficulties by saying that caloric was in the process itself called into being just as electricity is produced by the friction of amber.

Rumford, however, leaped to the conclusion that heat was due to the motion of molecules. This is

often expressed by saying that heat is a mode of motion ; but that statement seems to me unallowable for we cannot conceive of motion without something being moved, and neither that something nor the motion itself was either properly defined or even well conceived by the founders of the theory. Then, as showing that the matter is still unsettled, we have eminent authorities in our own day turning to the theory of caloric, and Professor H. L. Callendar has shown that it is possible to retain caloric as a working hypothesis.

It is curious here to remark that in an associated field there has been a similar return to conceptions which were supposed to have been annihilated, such as that of the corpuscular theory of light which Sir J. J. Thomson and the Einsteinians have revived in a modified form.

Rumford had found that caloric at least was not ponderable, but it is pointed out that the electrons which are the bearers of electricity are considered as imponderable. The adherents of the caloric theory say that it is something which gains energy on a rise of temperature. What this exactly means I do not know ; and it would be still more difficult to determine if caloric had no existence at all, but it does not seem to me more recondite, nor more meaningless, than the expressions which are almost universally adopted in modern physics, such as that energy is ponderable, or that it gains mass by

velocity. In one case and the other it would appear that there is no clear conception at all, but simply an attempt to express observed facts on the basis of a theory only vaguely apprehended.

One of the most luminous memoirs I have seen on the Carnot heat engine, is that of M. Daniel Berthelot, a son of the famous chemist, Marcellin Berthelot. He differs from the great German exponent of Thermo-dynamics, Clausius, who had condensed the expression of Carnot's principle into this form : "Heat cannot pass of itself from a cold to a hot body." M. Berthelot says that this enunciation is imperfect, and that the words should be added : "The heat current is never oscillatory." He says that in order that a form of energy should conserve its value it is necessary that the process should be reversible.

This notion of reversibility, or irreversibility, is the important new thing which Carnot introduced into the science : "What he has discovered is less a principle than an entirely new type of reasoning, which had not been employed before his time, and which has shown itself of such fertility that the consequences are not yet exhausted."

A discussion of Carnot's principle involves that of the conservation of energy, as Carnot himself perceived, although he did not give an explicit statement to that law.

Emboldened by Dr. Haldane's attack on a car-

dinal statement of Carnot, I proceed to lay hands upon, or at least tentatively to examine, the principle of conservation of energy itself! The most classic statement is that of Helmholtz, in a paper strongly fortified by mathematics. In the first place I remark that, by the force of mathematics alone, no such principle can be established.

Whenever a theory which depends on considerations of the constitution of nature appears to be proved by mathematics, it will be found that the principle is already tacitly assumed. That is seen to be the case in discussions of physical properties by Euler and Lagrange, before mathematics had acquired the forms which are considered essential to the study of the new physics; yet nature has always remained the same. Euler and Lagrange postulated conditions such that the problem came within the compass of their mathematical skill; and then they proceeded to give a learned display, not of the functions of nature, but of their power over the mathematical instrument. The same observation applies to a theory which had great vogue, and which still maintains its existence—that of the vortex rings of Helmholtz. If his demonstration be read attentively, it will be seen that the existence is implied of what he sets out to prove. We are discovering, not vortex rings, but the skill of a mathematician in carrying out a fine series of transformations.

So it is with this theory of the conservation of energy. It is probably true, but that statement makes an assumption, though again it does not follow that the assumption may not be verified. Suppose, however, that in the midst of this play of mathematics we deliberately and artificially introduce some new energy into the system ; then the demonstration would not run on the old lines. Yes but, it is objected, you have there done something not consistent with the course of nature. This remark alone makes it clear that the question cannot be answered without a complete knowledge of all the resources of nature or, if you please, a glimpse into the intentions of the Creator of the universe.

But let us take the matter on another plane. Certain forms of energy are continually being lost. If a bullet be shot vertically upwards it will come to rest after a time ; its kinetic energy has gone. Yes, the reply is, but it has gained potential energy. That means no more up to the present stage of the process, than that we have invented the term so as to make our theory tally. But soon we come to something new. If we dropped the bullet from the height it had attained, it would acquire at the surface of the earth the velocity with which it started. Here then we have something which we may call conservation of energy, but which it is better to think of as the reversibility of the processes

indicated ; this also involves an assumption, that of the constancy of the conditions of Nature.

Are these conditions really constant ? Within a short space of time, yes.

But suppose that we are passing through a certain phase in regard to the constitution of nature ; suppose, for instance, that what we call the attraction of gravitation may change, first by diminishing and then by becoming a repulsion, and suppose that electrical phenomena gradually change in an analogous way—what then ? There is nothing unallowable in such suppositions, for in the small realm of nature which we have been able to observe nearly all the great systems of forces are changed in some way successively by phases.

So much for the constancy of nature.

When we examine the other parts of the doctrine, that of the reversibility of processes, we find that there are sequences of phenomena in nature which, as far as we know, are not reversible. Even the Carnot Heat engine is not reversible without a loss, and the striking phenomena of radio-activity are held not to be reversible. Also the processes which take place in the galvanic cell are not carried on without apparent loss, when we estimate the amount of energy at the source and its ultimate product in external work.

Yes, the answer comes again, but the apparent loss is accounted for by the wastage in heat.

This is doubtless in part true, and there are other factors to take into account ; but it is also true that, subsequent to the demonstration of Helmholtz, other physicists of equal renown, such as William Thomson, afterwards Lord Kelvin, held theories as to the actions in the galvanic cell, which are not now accepted, and which actually ran counter to the principle of conservation of energy, although not intentionally. These at any rate are sufficient to show that the correspondence had not then been worked out, nor indeed since, between one form of energy and its representatives in the various transformations.

In an article which appeared in the *Revue Scientifique* in June, 1913, the well-known German chemist, Nernst, deals with the questions of the law of thermo-dynamics and that of conservation of energy in masterly style. I had not read his paper at the time when I had already arrived at the conclusions I have given, but I find in Nernst's exposition confirmation, reached at by another route and differently expressed, of what I have endeavoured to advance.

I do not quote Nernst by way of protecting myself by mere authority, for that would be contrary to the whole spirit of this book ; but I was so struck by the succession of his ideas chiming in with what I had found, that I cannot refrain from referring to him, if only to induce the reader to enjoy this handling of the subject by a man of great compe-

tence, both in the theoretical domain and in that of its practical applications.

It only remains to add that the law of conservation of energy, which is now considered something like the palladium of our science, met with a discouraging reception when Helmholtz first published it in 1847, and it was not until that great man of science had found fame in other directions that his confrères were induced to pay regard to his now celebrated law.

The law of universal gravitation has become so familiar to us that however far we may push our criticism in regard to less official theories, there seems to be an actual forbiddance in well-thinking circles to put in question the law of gravitation in any circumstances whatsoever.

Yet no attempt was ever made to establish the law as universal, nor is it clear how such demonstration could ever be afforded. Newton himself jumped to a conclusion. He gave us a grand generalization but this, like nearly all generalizations, involved many unproved assumptions. As, however, the science of physics has developed, especially in recent years, the universality of Newton's law has been frequently doubted. It does not apply to the ether, according to the usually received idea. Nernst says that it does not apply to bodies moving at a speed comparable to that of light. It is generally held not to apply to electrons. Once we have begun to question, it is impossible

to stop the tendency. Hertz and other great physicists, including Planck and all who follow him, have doubted whether the law was applicable to particles within molecular distances; and, finally, the question arises as to how we would become aware of a body which did not emit or reflect undulations within the range of our vision, and which was not subject to the law of gravitation. If such a body existed it might, nevertheless, have influence on phenomena which ultimately would become perceptible to our senses.

There is another aspect of the law of gravitation, which is unsatisfactory. It merely expresses a relation, but gives no suggestion of any kind of mechanism or of processes by which the law operates. Thinkers have never been quite content with the notion of action at a distance, nor was Newton himself, and various mechanisms have been suggested since his time, in order to fill up the hiatus in our minds as well as to connect the intervening distance. None of these have been satisfactory, so that one of the greatest and most interesting of problems is still open to the public.

Another theory, more fundamental still than the law of gravitation, has given us the parallelogram of forces. A man must be an iconoclast indeed who attempts to meddle with the parallelogram of forces, therefore I content myself not with denying its use as a good working conception, but with refusing to accept as satisfactory any of the demonstrations that

have ever been put forth as to its truth. Laplace has felt the necessity of proving this principle, but his demonstration really already assumes it.

Imagine for a moment a body acted on by two forces, which can be represented by straight lines of equal magnitude, one pointing north and the other east. The body will then be carried in a direction north-east by a force equal to the diagonal of the parallelogram which, in the case mentioned, would be a square of the forces in question. If the demonstration were given by supposing the eastern force to act alone for a certain time, and then to cease, to allow the northern force to operate for the same time, the result would certainly correspond to the parallelogram of forces, but the demonstration would appear a little crude. What is really done, therefore, is to carry out this process for very short intervals of time successively, imagining a very short pull to the east and then a short pull to the north, then to the east, then to the north again, and so on. The assumption, however, is really as great in this case as in the other, except that it is not caught in *flagrante delicto*, and we are satisfied with this concession to the *convenances*.

If we imagine the forces acting on an ideal particle without size or chemical constitution, I confess I can form no conception whatever by sheer dint of thinking, as to what should happen, though, aided by experience, I say cheerfully that the system

would obey the law of the parallelogram of forces, with the tacit reservation, no doubt, that the system could not exist. But in Nature we deal with real objects, and if we put one of those in the place of our ideal particle, then we come in contact at once with a whole series of circumstances,—atomic constitution, cohesion of atoms or molecules, elasticity, and so forth—which we ignore in our law. The actions which take place must not only be very complex, but really incalculable.[1] In this reduction to practical conditions, we see still more clearly that there never has been a demonstration of this principle at all, except that of an appeal, direct or indirect, to experience.

[1] The difficulty depends not only on the complexity of the atom, but on the elusiveness of "force." Nernst, for instance, holds that the ordinary conception of force, that which constitutes its very definition, does not apply in the case of the shock of atoms; while as we have already noted, many thinkers, including Lagrange and Hertz, have felt that in applying the term "force" they were simply invoking a spirit. I do not mean to argue that the use of the concept force has not aided the development of physical science, I only desire that those who deal in such terms should know what they are doing.

Even the term "centrifugal force" may be convenient if we know what it implies. And so with other terms, such as imaginaries, infinity, the circular points at infinity; the generalizations of Lobatschevski, Bolyai and Riemann, and the further extension given to these conceptions by Einstein; even "time-space" about which Silberstein discourses with virtuosity; these terms are admissible if we confine their application to their true import and do not allow ourselves to be misled by unwarranted implications.

That ground is no doubt sufficient for all practical purposes, such as the calculation of stresses on the girders of bridges, but we must not suppose that by speaking in highly technical language and describing in that manner the observation and experience, that we have given an independent and rigorous demonstration.

For the moment I take leave of the domain of physics, in which I have touched, not in order to give any account of the present conditions, but simply to show instances exemplifying my main theme. Physical science is, I believe, in a more healthy condition than any of the others, and our own schools of physics have within recent years shown a veritable new birth of genius. It is not only men well-known, Sir J. J. Thomson, Sir Ernest Rutherford, Sir William Bragge, who have done great work in this domain, but a number of others, my colleagues in the Physical Society, some of whose names are destined yet to shine out as beacon lights. Moreover, in all the civilized countries one finds the like enthusiasm and extraordinary zeal on the part of devoted workers, reminding one of the rush of an army of conquest where position after position is attacked and captured, and where, from rank to rank, from force to force, from continent to continent, the signals are thrown forth and exchanged, telling of new triumphs, and of new possessions added to this wonderful and fascinating domain of the mind.

CHAPTER SIX

DOGMAS OF SCIENCE—CHEMISTRY

THE modern science of chemistry is lineally descended from that of alchemy and, although the old alchemists were at one time derided, some of the great modern chemists, Sir William Ramsay, for example, have treated them with a reverence due to ancestral pioneers. This attitude seems to me to be correct, for the struggle of the alchemists to raise their science on a sure basis appears to have been prolonged on similar lines even when chemistry had become a modern science, such as in the main lines we now know it.

Lavoisier is now considered to be the founder of modern chemistry, or, at any rate, the great organizer who brought clear conceptions applying to the whole domain, and indicated the course of future development. For two centuries, however, before Lavoisier, the science of chemistry was dominated by the conception of Phlogiston, which was regarded as a substance even though its qualities were not very clearly defined.

One of the great protagonists of the phlogiston theory was Stahl, who had acquired vast knowledge

of chemical phenomena within a certain range and who, by his unwearied research and grouping of facts, had secured a position of dominance in the scientific world.

The phlogiston theory led him to such conceptions as this : That when two bodies united together there resulted a loss of weight. To our modern eyes this looks like a palpable absurdity but, as we have already seen, we are prepared to accept, in the forefront of our new science, conclusions which, if not palpable absurdities, seem to run counter to what we know in wider experiences, just as Stahl's explanations ran counter to common-sense. Yet these conclusions were accepted, for there are two modes of reasoning in scientific circles; one of them being that doctrines laid down by a high official person, backed by the authority of all the Universities, must be correct ; the other, having a much humbler aspect, being that the responses of nature to our questions are always correct.

Lavoisier adopted the modest view, and he made a series of experiments in which he traced out various combinations of chemical substances, and on the basis of which he asked : Where has phlogiston entered into the matter at all ?

There was no clear answer and, as his experiments proved that when two bodies united the weight of the combined system was equal to the sum of the weights of the parts, then phlogiston had received a

blow comparable to that given by Galileo to the science of the Schoolmen.[1]

There is something extraordinarily fascinating in tracing out the gradual development of the science of chemistry. We find a succession of events of this kind. Some bright mind, looking into an obscure region of ill-arranged facts, makes a discovery. The discovery meets with great opposition ; but when it corresponds with conditions of nature, it becomes eventually recognized, even though perhaps a whole generation of fossilized brains must have been interred in the interval.

The discoverer erects a theory round his discovery, and magnifies its importance enormously in regard to the illimitable vastness of the subject. The theory is gradually found to be insufficient, and the discoverer uses all his acquired authority to contort facts into accordance with his preconceived ideas, and to delay the march of science.

In some cases that result has been brought about by defects of character of the thinker, by foolish vanity and obstinate pride, or for other even less commendable reasons ; but in many cases good, honest, simple souls have been misled by seeing too clearly in concentrated gaze partial truths they have

[1] Landolt and Heydweiller found, after five years' elaboration, that the change, if anything, must be less than 1 in 10 millions. J. J. Manley, of Oxford, found in the chemical combination of barium chloride and sodium sulphate no change greater than 1 in 100 millions.

found, while at the same time they have not possessed the elasticity of spirit to see them in their proper relation.

Two or three lines of thought in chemistry are worth noting briefly. Dalton is considered as the founder of the atomic theory, and that is the bedrock of the modern development. Dalton, simple, unpretentious Quaker as he was, gifted with a clear intellect, yet showed remarkable obstinacy in adhering to his wrong determination of atomic weights. The date of his theory may be taken as 1803. Ten years after Avogadro, in 1813, announced the law that, for a given volume and pressure, the number of molecules of gas contained in the volume was always the same.

Following along what we may call structural lines for the moment, Frankland and Kekule, in 1852, put forth the theory of valencies, of which the general conception is that the atom of an element might combine with one or with two or with three atoms of another element; thus, for instance, taking hydrogen as of unit valency and oxygen as of valency two, two atoms of hydrogen would unite with one of oxygen to form a stable compound.

Kekule imagined a certain structural form, exhibiting the mode of union of the atoms, and so made a real advance beyond the expression of the relations by a mere formula. Then, taking up another line of research, we find that already in

1815 Biot had observed that certain liquid organic substances deflect the plane of polarization of a transmitted ray of light either to the right or to the left. Half a century later, Pasteur and Paterno arrived at the conclusion that this effect depended upon some peculiarity of structure, giving right-handedness or left-handedness to the figure of the molecule.

In 1874, van't Hoff and Le Bel attained greater heights by imagining models showing the relations in space of the atoms of the molecule.

Then followed a vast amount of research, led by von Baeyer, Emil Fisher, Wislicenus and others which, at length, on the basis of experimental data, established van't Hoff's theory.

Then the structure of the atom itself became the subject of inquiry, and first J. J. Thomson conceived a model representing the relation of the electrons to the nucleus, and this conception was afterwards modified and improved by Rutherford and Bohr, giving us the "astronomical atom."

It is worth while noting here that this conception of the astronomical atom was first put forth, as far as I can find, by Dumas who, although he depended upon little beyond scientific intuition, gave a clear statement of this atomic system.

Then we have the work of Sir William Bragge and others who, developing the conceptions of their predecessors still further, have worked out in great

detail the disposition of the atoms in the structure of crystals. When one sees this whole work in perspective, it is of dazzling brilliance, although, looking at it a little more nearly, it has been reached by successive steps, each of these steps having demanded a fine effort of thought.

Alexander Bain said long ago that Davy's feat in the discovery of the metal potassium was that of searching for the secrets of nature in the very thickets of concealment ; but, although one must always give the highest credit to the pioneers, I incline to think that the entire work which has resulted in determining the figures of the atoms has been still more wonderful.

In the history of modern conceptions of chemistry and electricity, the name of Humphry Davy often occurs. There are two types of scientific workers who are sharply distinguished : What might be called the orthodox, and classical type is that of a slow, methodical, careful worker, chary of hypotheses, but meticulous in securing accuracy. Of such a type was Berzelius, the great Swedish chemist. There is another type—eager, impatient, filled with a poetic afflatus, prone to make guesses, some brilliant, others less successful, but with no very clear criterion by which to prefer one to the other, and apt, indeed, to insist on a faulty supposition. Davy was of this type.

The appearance, temperament and style of the

man reminds one of a dashing leader of cavalry, and his work has something of that impress. He made wonderful guesses, certainly arising from a mind steeped in the subject and prone to speculation. These he tested summarily, and in quick, eager style.

When he first saw the metal potassium produced in his laboratory, Davy leapt and danced about the room like a corybant in a Bacchic festival. Truth to tell, there was enough to excite him. He had beheld what no mortal eye had ever seen before, and he had opened up new vistas of thought and triumphs of human intellect. He stood upon his "peak in Darien."

Davy had in his disposition a strong component of vanity; amiable and generous in its original nature, he had the misfortune to marry a rich lady who saw little in science beyond the access which her husband's fame gave her to exclusive circles of society.

Faraday had entered Davy's laboratory first of all as a sort of happy compound of charwoman and scientific assistant and, when Davy accepted an invitation to France—Napoleon having accorded him the unique privilege of coming unmolested and welcomed during the unsettled period of the great wars—he brought Faraday with him as his valet. On one occasion during a "shoot" which was given in Davy's honour, Faraday accompanied

the party in the capacity of a gillie. In the course of the day, however, Dumas, who was, like Faraday and Davy himself, of undistinguished origin, dropped behind and entered into conversation with the lackey. He was astonished at Faraday's replies and by the whole style of his conversation, and the more he questioned and listened the more his wonder grew. On returning to Davy he inquired about Faraday who, when not a valet, was, so Davy told Dumas, an assistant in the laboratory.

"Yes," replied Dumas, "but he is a man of science certainly on a par with us, and I intend to invite him to dinner with us."

Davy himself had no objection, but Lady Davy was outraged at the idea of a mere man of genius sitting at the same table with people received into the best society, and nobly maintaining her dignity in these trying circumstances she flounced out of the room and forthwith returned to those circles where her action was appreciated and her wounded feelings received due consolation.

Faraday, who was himself a very simple-minded man as far as his worldly ambitions were concerned, was a member of the Glassite faith, perhaps inclining to Sandeman's persuasion rather than adhering too rigorously to the tenets of the Upstanding Glassites. This little sect gathered at a humble meeting-house in Clapham, where, amongst other ceremonies, they indulged in weekly "Love Feasts";

but as none of them were blessed with worldly goods, the love-feast often consisted of a bowl of porridge and milk into which they all took a dip.

One cannot withhold an affectionate admiration for Faraday in remembering that even when world-famous, patronized even by Royalty, he still found joy and solace in a "Love Feast" in the circle of his old friends.

At this time he had equalled Davy himself in fame, and in his methods he combined in some measure the daring spirit of speculation of his master with the careful methods of Berzelius.

In Davy's first attempts to penetrate the mystery of chemical action and its association with electricity, he imagined that the atoms did not become electrified until actually in contact, or approaching contact. This suggestion has not been verified but, in opposition to Berzelius, he had the true view of chemical combination. Berzelius had imagined that all chemical combinations took place in unions of bases and acids. Davy, on the other hand, held that in these combinations there was a metal on one side, this being the positive element and, on the other, a negative element which might be simple or compound. The difference of theory came to a definite issue on one occasion when Davy was able to convince Berzelius that a certain constituent was an element, chlorine, and not, as Berzelius had imagined, according to his theory, a compound of a

mythical murium and oxygen. After this clash of views, in which the conceptions of Berzelius received a rude shock, one might have expected that he would revise the whole theory. Instead of that, he defended it with still greater obstinacy, and spent the last years of what had been a very useful life in trying to set science upon a wrong track.

The manner in which the positive and negative particles existed in the electrolytes of a battery remained uncertain until Grotthuss arrived with the suggestion which for a long time satisfied the scientific world ; that is to say, after it had been accepted, for in the early years it met with either indifference or discredit. Grotthuss, a Count of Courland, is himself a figure rather from the Arabian Nights than of the dry pages of the history of science. He had all sorts of adventures, even to the robbery of his scientific papers by brigands, who showed for once a zeal for knowledge difficult sufficiently to extol. But after all, his one achievement was that of the Grotthuss hypothesis.

He imagined that the molecules could be represented as particles having a negative pole at one side and a positive at the other, the positive side joining on immediately with the negative of the next in order, and so on until the chain was completed between the two electrodes. Where positive and negative met, they balanced each other, so that the final result was a negative ion, as we would

now call it, at the anode, and a positive ion at the cathode.

The next great figure in the series of those who were building up the science is that of Wilhelm Hittorf who, not quite content with the schematic explanations of Grotthuss, looked more deeply into the actual processes of the system, and made a series of valuable observations and measurements on the relative concentration of the ions in different parts of the cell.

Meanwhile, a great number of experiments had been carried on with reference to the phenomenon of osmosis. In a science not immediately connected with electricity at all, Pfeffer, having studied the curious phenomenon of the pressure within the cells of plants, sometimes many times greater than that of the liquid outside, hit upon the idea, which he successfully realized, of making an artificial cell by means of which he could study the matter more effectively.

His experiments were followed by those of van't Hoff, which finally resulted in the enunciation of a law which expressed that the molecules in a solution were in a state comparable to that of a gas, and that the laws of osmosis must be interpreted in accordance with this conception. When van't Hoff first propounded this theory, he was a comparatively unknown young man, and his reception at the hands of the great authorities of the day was very dis-

couraging. One of them, Kolbe, a celebrated chemist and rector of the University of Leipzic, belaboured him in the most approved style. He insulted him, as being connected only with a veterinary school, instead of appearing as the representative of a reçognized University and, in this manner of official wit, he succeeded, or thought he had succeeded, in smothering his opponent in a chorus of laughter of the scientific world. All this was entirely correct and orthodox, but what followed was extraordinary. Subsequently, Kolbe on looking into the matter more attentively and verifying van't Hoff's experiments, concluded that the Dutch chemist was right after all, and in a most magnanimous manner he stated this in public, and apologized for his own previous rudeness.

Van't Hoff marched from success to success, and gave a great impetus to the study of electro-chemistry.

He was followed by Arrhenius, still happily living with us as the famous Nobel Prize-winner, but at that time a young and unknown man. He put forward a theory more audacious still—that, in chemical solutions, a large proportion of the ions were in complete disassociation and that it was by virtue of this fact that the laws of electrolysis might rightly be interpreted. These early views of Arrhenius were greeted with derision in the orthodox world, but they have since become almost universally accepted.

One little point I have never seen properly elucidated is this: Since a combination of these ions produces heat, and since, therefore, some equivalent of potential energy is implied in their disassociation, how does the mere process of solution operate to produce this result, and where is the evidence shown of the corresponding transformation of energy?

There is another line of research along which chemical and electrical science has been developed, though all these, of course, mutually influence each other. One of the great events in the history of the world was the observation by Galvani that the legs of a frog twitched when they completed a circuit between two different metals. Galvani attributed this phenomenon to something of vital force in the frog's body, and this suggestion was taken up with extraordinary enthusiasm. This was only in part due to its scientific merits, which, in fact, we now know to be nil, but there is always a strange tendency on the part of the public to revolt from what they call materialistic explanations of phenomena, whenever any organic organism is concerned. You will see this recurring again and again, but never once in the sense of elevating science, as they suppose, but rather with the effect of putting unnecessary obstacles and entanglements in its way. What we have always to consider in science is not whether one explanation makes a greater spiritual appeal than another, especially when false ideas of

spirituality prevail, but simply whether something is so or not in the course of nature.

Volta gave another explanation to the whole process, attributing the phenomena solely to the contact between the two metals and, by a long series of experiments which produced as a crowning result the Voltaic Pile, he convinced the world of the rightness of his own conceptions. He convinced the world of too much, for it now appears that Volta, though he corrected Galvani, was himself in error to an equal degree in missing in his explanation the processes taking place in the electrolyte.

Volta looked with disfavour upon the subsequent researches which tended clearly to show the part played by the electrolyte, but he differed from many of his predecessors and confrères in contenting himself with only a passive resistance, and not an active obstruction to the progress of science where it ran counter to his own theories. Living in retirement near Lake Como, Volta regarded these aberrations, as he thought them, in a philosophic and indulgent mood. "Time will correct all that," he said.

Volta's own conception implied the reality of what is called perpetual motion. That is to say, mechanical work without the transformation of energy ; but he was also quite content with that state of affairs also, and when anything was brought to his attention which contradicted his ideas, or which seemed to be a noteworthy phenomenon

deserving of study, Volta still smiling happily, replied : " The Pile is such a wonderful thing, that anything might happen ! "

One of the first of those to push ahead in new developments was a young German chemist, Ritter, who put forward the theory that the real source of energy was to be found in the chemical changes in the electrolyte ; but Ritter's theories found no acceptance during his lifetime. They were, however, very seriously taken up by a Danish physicist, Julius Thomsen ; in the course of experimentation he noticed, and then studied attentively, the great disengagement of heat in the galvanic cell, and he affirmed that this might be taken as a measure of the chemical energy of the reaction which finally produced the current. This was in 1852, and in 1869 Berthelot, the French chemist propounded a law to the effect that all chemical change which takes place without the intervention of outside energy, tends to the production of the body, or system of bodies, which disengages most heat.

That theory is not now held, but it was long defended by Berthelot, although it seems to be disproved already by a remark of Horstmann, that chemical reactions can be carried out at times in one or the other sense following upon a change of concentration ; but evidently in both cases could not tend to the production of the system disengaging most heat.

One result of Berthelot's theory, however, was very suggestive for, if his theory were right, he had indicated a mode of calculating the electro-motive force of a voltaic pile.

We next come to the name of William Thomson, afterwards Lord Kelvin who, in 1851, propounded a law which stated that the "intensity of an electro-chemical apparatus is, in absolute measure, equal to the mechanical equivalent of as much of the chemical action as goes on with a current of unit strength during unit of time."

In this law Thomson revived the old theory of Ritter, and ignored the so-called law of Berthelot. Thomson's law had everything in its favour. He himself, though still a young man, had a high reputation, his theory was expounded by a great display of mathematical formula and, moreover, it was verified by certain experiments which had been carried out with that end in view.

Here was a process the reverse of that to which we had already become accustomed, of obstinate and unreasoning resistance to a new theory. That resistance has generally been most vehement when the theory has been right. Thomson had a very favourable reception, but his theory was wrong.

About this time a great number of experiments were carried out with a view of estimating the mechanical equivalent of heat, and Helmholtz had already written his memoir on the Conservation of Energy.

A French physicist, Pierre Antoine Fabre, had devoted himself to the examination of the heat produced in the battery itself, and Raoult had virtually founded a new branch of chemistry in the study of electrical processes at low degrees of temperature.

Meanwhile, too, Faraday had produced one of his greatest results by showing that the weights of the elements liberated in a given time from chemical combinations are proportional to the chemical equivalents of these elements. With these acquisitions in hand Helmholtz at a later period, and Gibbs, in America, undertook a series of observations and experiments which resulted in the conclusion that the so-called Law of Thomson was not true in those cases where the electro-motive force of the system changed with the temperature and, finally, that it was only true at the absolute zero of temperature.

The science of electro-chemistry is thus seen to have been one of extraordinary interest at every stage of its development and, no doubt, for the reason also that it has produced practical results of vast commercial value. It has now linked on to that other branch of science, molecular physics, which we have discussed. This tendency of one science to impinge upon another is not casual ; it simply depends upon the width and depth of our scientific vision. It shows us also that the best kind of "specialism" is that which secures mastery of the results of allied branches of sciences. What

will be the next development? It is evident that we have already met with paradoxes for which only lame and tentative explanations have been offered. Now paradoxes really do not exist in nature. Nature is an honest being, which invariably answers our questions immediately, and with complete precision. The paradoxes arise only from confusion of our own minds.

One step towards the true solution is to acquire sufficient courage to be indifferent to the display of great names or academic authority; for already we have seen abundance of examples to show how small a matter is that in view of the consistency of nature.

I have noticed of late, not in an entirely receptive mood, a disposition to revive, as by Professor Callendar, the old theory of Caloric, and also on the part of M. Vasilesco Karpen a return to certain of the ideas of Volta about the action of the pile, for M. Karpen has the courage to state that he has found a system which, after years of experiment, seems to contradict the second law of thermo-dynamics.

It is never of any use, except for practical purposes in the world, to seek to deal with a difficulty simply by ignoring it. Rather there is wisdom in the observation of Gauss, that it is on the little obscurity, the annoying inconsistencies of a theory, that we should concentrate our attention for, in the removal of a paradox, we often light upon a new truth.

CHAPTER SEVEN

THE SACRED SCIENCE—BIOLOGY

ONE of the most fascinating realms of science is certainly that of Biology.

In the succession of fashions of science, biology had a special vogue in the last two quarters of the previous century. It became the "Sacred science," though its title to that distinction and its fashionable favour have been displaced by that of physics which, though at first sight somewhat severe in its beauty and not entirely facile in its attraction, yet conceals the mysteries of Relativity and offers the continual promise of getting in touch with spirituality by means of our acquaintance with the ultimate forms of material.

Hitherto, in the course of our reading in the present book, we have proceeded from the more demonstrable sciences to those in which the modes of proof were becoming tentative.

In biology, and especially in that region of it which deals with evolution, we escape from the exigencies of stringent proof, and we delight in the happy hunting-ground of imagination. That is, possibly, one of the reasons why, in this science, dogmas have become so common, and elusive truths

have been maintained with so much temperamental heat.

It may be said formally at the outset in order to fix our ideas to definite points, that in ancient times and up to a quite recent modern period, two main theories disputed the ground. One was that of preformation and the other that of epigenesis.

The Preformationists believed that the future development of the organism was already determined and, in fact, exhibited by the material contained in the egg itself ; the upholders of epigenesis, amongst whom was Aristotle in the old days, believed that the course of development was modified by the various factors of the environment in which the organism exercised its life.

For some reason which is not quite easy to understand, the Preformationists have rather plumed themselves upon a higher religious standpoint than the Epigenesists.

The first biologist of great note in the modern series was Lamarck, who, in the year 1809, propounded his doctrine that variation of species was due to development of limbs and other organs by use ; or the corresponding retrogression by disuse, respectively. The characters so acquired he believed to be hereditary. Fifty years later, Darwin published his famous book, *The Origin of Species* in which, while recognizing the part played by the Lamarckian factors, he regarded them as insufficient

to produce these definite changes in species which he observed, and he brought into prominence the principle of natural selection.

Alfred Wallace, who had been working quite independently of Darwin, had anticipated him by the publication of a pamphlet running on the same general lines.

Herbert Spencer, the philosopher, became an ardent champion of the doctrine of evolution, and it is to him that the phrase is due : The survival of the fittest. Spencer was, however, a determined champion of Lamarckism. The German biologist, Weismann, then appeared upon the scene with a theory which was much stronger on the negative than on the positive side. He asserted that acquired characters were not inherited, and he backed up his arguments by a series of observations and experiments marshalled together in a very impressive manner. His own theory, though expressed in technical terms, and set forth in a very elaborate style, was really a throw-back to the preformation doctrine.

Another series of explanations followed, led off by the doctrine of fluctuations, of which the main upholder was a Danish biologist, Johannsen. Then the Dutch botanist, Hugo de Vries, put forward the theory that changes in the organism took place, not by gradual evolution, but by sudden leaps which he called mutations.

The next great figure noticed is an Austrian monk, Gregor Mendel, who, as the result of his observation on a species of peas, formulated the laws which have since been the object of a vast amount of research and study. About the same time that Mendel was working, a French botanist, Ch. Naudin, had also obtained similar results.

Of late years a great deal of the work in the biological field has consisted in the testing and development of the suggestions put forward by de Vries and Mendel, but no new striking theory has emerged.

In this very rapid indication, a number of names, even of great celebrity, have been passed over, not because the work they represent has not been interesting, but because it was associated with refinements or corrections of previous theories rather than with the introduction of a new and important principle into the science.[1]

[1] Nägele, after elaborate experimentation, especially with the Hieracia alpestris, was led to believe that the modifications produced by change of nourishment, of climate, of environment, were not "acquired," and had no influence on species. He therefore proposed a theory which, though very different from that of preformation, finds nevertheless the chief causes of evolution in the internal conditions of the organism.

His views were adopted with some modification by a noted Belgian palæontologist, M. Dollo, who struck out a new line, supported by numerous observations tending to demonstrate the irreversibility of evolution. That is to say, if an organism in the course of its development became mobile in sea water and developed

Darwin's work, as we have already remarked, was important not only for itself, but for the manner in which it clashed with orthodox beliefs. Bishop Wilberforce said that it ran counter to the Word of God, but he was not entirely convincing in regard to the channels by which he obtained this Divine assurance; and, moreover, when Darwin, backed up or rather led on, by so doughty a fighter as Huxley, had swept the field of his opponents, at any rate in the scientific world, the adherents of Bishop Wilberforce showed a readiness of adaptation which, as it has been found hereditary, would have satisfied Lamarck himself.

The good Bishop received much kudos in his day for his unflinching defence of error, but even his zeal paled its ineffectual fires in comparison with the faith of Hugh Miller, who declared that, rather than accept the doctrine of evolution, he would believe that God Almighty had Himself stuck all the fossils into their various strata as an

with the addition of fins, and then subsequently returned to a condition of immobility, that new change of state was not marked by reversal of the process that had made it a swimming organism. It developed new apparatus in accordance with its new mode of life, and the fins became gradually atrophied in the course of time among its descendants. Associated with this line of work questions of atrophy of parts through disuse and forms of change by retrogression have been studied by Demoor. The suggestion of Daniele Rosa should also be noted, that the conditions under which evolution is now taking place may give us an insecure guide as to the activity of variation in the past.

example of those mysterious ways in which wonders of the moral world are performed.

I confess it seems difficult to rebut an argument of this sort, and, in order to meet it, I feel myself pulingly restrained to search out that old doctrine of Pythagoras, which already we have treated with smiling superiority,—the doctrine, you will remember, that the planets move in the path where it was seemly and beautiful that they should move. It is possible to conceive that the Devil, in view of the excessive licence which is permitted to him, had carried out a grandiose and Mephistophelian plan—now or never is the time to use that word—in order to try our faith and delude us to our destruction; but that the Deity should comport Himself by sticking in multitudes of fossils in incongruous places, and apparently for the like purpose,—no, that does not seem consistent with the dignity of an Omnipotent Being.

If I have dwelt upon this matter for a moment, the fault is not entirely mine, for the authors of such sayings as that of Bishop Wilberforce, or as that of the great Scottish defender of the faith, reaped thereby far more fame than Darwin won in these critical hours of combat. Had the question been decided by popular suffrage, they would have been swept in to the top of the poll in a wave of national enthusiasm.

Darwin himself was fortunate not only in the

possession of a peaceful spirit, but also in that of a comfortable income which made him independent. His predecessor, Lamarck, was less happily circumstanced. In his day Cuvier was the great authority in natural history, and certainly he had not usurped that position.[1]

Cuvier was the very model of a great academic figure, President of learned Societies, high authority in the world, for he was not only extraordinarily gifted in many respects, endowed with a prodigious memory—it is said that he could recognize a bone that he had once seen, perhaps years before, not by reasonings associated with it but by its mere appearance—he was entirely orthodox, well received at Court, a credit to his nation and a shining light to succeeding times. And yet withal it must be said that Cuvier's influence upon science was retarding and detrimental. He held ideas as to the antiquity of the world which now seem to most of us puerile, but which acted at that time like an 'Open Sesame' to academic honours.

He fell foul of Lamarck and, as he had a fine literary gift and great power of expression, he not only crushed Lamarck out of recognition, but, in-

[1] Cuvier was an extraordinary genius; his brain is still used, by the way, by the phrenologists, to throw at those of us who doubt that the mere size of the cerebrum is itself a decisive indication of genius, for Cuvier had one of the largest brains on record; though even he is beaten, and handsomely, by a village idiot whose fame rests on this record alone.

directly, deprived him of his livelihood. Lamarck lived the last years of his life in poverty, almost forgotten by the world, sustained only by the affection of two or three who were near to him, and who bade him remember always that posterity would do him justice. When he died he had not left sufficient money to buy a grave "in perpetuity" so that, when long afterwards his admirers met in Paris, coming from all over the world to render homage to his name and work, they were unable to discover the ground wherein lay his bones.

The theory of Lamarck is very attractive at first view. Most of us can remember having considered the figure of the giraffe with a sort of expectant sympathy, tracing out his progression as a consequence of his desire to reach higher and higher things, and inducing Nature to come to his aid by virtue of his own incessant efforts. The form of reasoning here is insufficient, because it is not actually demonstrated that the results described actually do follow from the causes given, but the manner of the argument is still popular, as we shall see, among the opponents of Lamarck, including the orthodox Darwinians who rely almost entirely upon natural selection.

In regard to the giraffe itself, it should be noticed that it was not sufficient for him to cultivate an elongated neck, but that his legs and his head and tongue and his body and, finally, his vital functions

must also be adapted to much the same ends. This is only a slight indication of the lines along which Lamarck's theory was criticized, and it was vulnerable from the fact that he, like nearly all expounders of favourite theories, placed too much weight upon its shoulders.

Lamarck himself has been reproached by Sir Ray Lankester, amongst others, with not having sufficiently supported his theory by observations and experiments.[1]

In a letter to *Nature* in 1894, Sir Ray Lankester asserted that Lamarck's first law contradicts his second. The first law is to the effect that a new stimulus alters the characters of an organism, while the second affirms that the effects of previous stimuli are fixed by inheritance. There does not, however, appear to me a contradiction between these two laws, for the first law has in view the alteration of characters which had been "fixed" but not within the limits of being unalterable by new stimuli.

Lamarck has come into favour again ; both in this country and in France especially, some form

[1] One of the most striking results in regard to the hereditary character of acquired faculties is due to the director of the Biological station of Vienna who, writing in 1913, describes his experiments on various species of Salamander, in which he changed the conditions of dryness and humidity as well as the character and colour of the soil. He concluded that the variations produced in response to the change of conditions became hereditary.

of Lamarckism is maintained by the most authoritative biologists, and Le Dantec has published a book tending to the rehabilitation of Lamarckism.

On the other hand, a great number of special studies within restricted paths have been carried out, tending to show the validity of both of Lamarck's laws. For example, an American observer has studied a number of generations of race-horses; the results so far afford some verification of Lamarck's doctrine.[1] Others have studied physical disabilities, or even positive diseases such as hæmophilia, and conclusions derived from this source also are believed to give some support to Lamarck.

The question of immunity in the new-born child is also important, and not far dissociated from that of the effects of poison on the maternal system. Dr. Roux, of the Pasteur Institute, recently presented to the Academie of Science some interesting notes in this regard, by Netten, Larrier, G. Rameau and Grasset; these certainly tend to show some transmission of acquired characters. Sir

[1] Amongst the many cases where observers have found, or thought they had found, that certain acquired characteristics had been inherited, a curious fact pointed out by Sir Arthur Keith is well worth noticing.

He remarked that the flexion lines on the palm of the hand, which are generally assumed to have been induced by use, appear also on the fœtal hand before the corresponding movements have begun. Keith is inclined to take this as evidence in support of Lamarckism, and certainly it seems difficult to explain it on the assumptions of any rival theory.

Arthur Keith has also studied this matter, with results which accord with those above.

It is necessary to make a distinction between a true transmission and that which is produced by the direct communication through the placenta of maternal blood with that of the embryo.

It is evident, however, that Lamarckism in itself alone is not sufficient to account for the production of species.

The law of natural selection, when first presented, has an appearance still more fascinating than that of Lamarck. One remembers the delightful description of how all the fleas in the desert become grey, or how the Polar bear becomes white ; and the narrative is so smooth and instructive that one scarcely notices that the successive changes appear in due time just as if nature were a prompter giving the cue to a favourite actor. The fault here is similar to that of Lamarck's exposition, though possibly not so glaring ; that is to say, there is a notable deficiency of a closely causative series and an absence of quantitative proofs.

Then again, when we come to examine the question a little closely we find all sorts of difficulties. If the white of the bear's coat arose as a result of purely accidental or "spontaneous" causes, it would hardly become white all at once, and it is probable that a parti-coloured coat might be more visible to the victims of the Polar bear than a uniform coat,

even though not originally of the best colour. But looking into the matter with still greater nicety we see that the change of colour does not arise in a " hey presto ! " style, but that it is due to modifications in the pigmentary cells, which again are dependent upon a variety of influences arising from the functions of the body. It is facile to pass these over in an off-hand way, but a French botanist, Guilliermond, has concentrated on the study of the pigmentation of carrots, and one arises from a reading of his observations with the sense that these matters, if explained at all, must refer to the co-operation of many physical and physiological factors.

These factors are not under the control of such causes as change in environment in itself while, on the other hand, sudden changes in environment may produce important changes without reference to their advantage or otherwise in the new sphere of life. In the narrative of one of the Voyages of Sir John Ross he tells of an animal that was kept in the cabin and subsequently brought upon the deck under a temperature of thirty degrees below freezing. The fur on the cheeks and a patch on the shoulder became white in the course of the first night, and at the end of a week it was entirely white with the exception of a dark band across the shoulders, which was extended posterially down the middle of the back.

Professor A. C. Geddes, of Dublin, also records

a case where a cat was shut up in a refrigerator in Sydney by mistake, and kept there until the vessel reached Aden. The fur of the cat had become white, but it recovered its normal colour before the voyage was at length completed.

Professor Barcroft, who has especially studied the question of pigmentation, has made observations on the winter fur of the hare, and other animals; the result of these is to show that the effect of cold in itself is to produce or tend to produce fur of white colour. Amongst a series of other observations on the effect of temperature upon colour, one may cite the interesting studies of H. M. Vernon on the colours and markings of lepidoptera. The Vanessa levana has yellow and black patterns on the upper side of the wings while V. prosa has black wings, with a broad white transverse band. V. levana emerges in the spring, breeds immediately and produces adult V. prosa in the same summer. The progeny of these insects in turn pass the winter as chrysalids and emerge the next spring as V. levana. These were formerly regarded as different species, and no doubt their changes in colour would be explained by the most orthodox Darwinians, if one conceded the right to offer explanations which simply restated the observed facts in terms of a theory, while neglecting to show the effective action of the supposed causative factors.

A consideration of all these and allied facts,

induces one to demand from the theory of natural selection something more than the mere relation of sequences in the connection with observed facts.

Proofs of another kind were brought forward by the celebrated Ernst Haeckel, and it was to him in regard to the Continent as much as to Huxley in England that the popular success of Darwin's work was attributable. Haeckel had all the qualities which go to make a popular exponent of science, including that of an emphatic style and a sort of ethical faith which pleased the public, naturally inclined to be impatient of scientific hesitations.

Haeckel saw the end to be attained and he often bent to that service not only the form of his argument, but the description of facts themselves. In more than one instance he deliberately perverted these facts by exhibiting in his drawings certain forms which were not found in Nature. For instance, he pictured Haliphysema drawn with a pretty collar of cells which he had imagined less for the use of the creature than for the purpose of his own argument. He is the great exponent of the theory that the embryo in its development reproduces in turn the adult stages of ancestral types. This is called the Biogenetic law of Recapitulation, and tends to show correspondence of "ontogeny" and "phylogeny;" and Haeckel who, in the course of

his explanations invented technical terms which gave an imposing air to his theory, claimed this law as the definite proof of Darwinism.[1]

T. H. Morgan, of Princetown University, in his *Critique of the Theory of Evolution*, submits Haeckel's law to criticism which leaves it little of value, though Morgan holds that the common features of the morphology, that is to say, the form and function, of the embryo indicate, in the mammal and the bird, a common ancestor, and thus the law accords so far with the doctrine of evolution. Professor Morgan, who is a great light in the biological world, takes his position as an upholder of natural selection, supported by the introduction of the principle of mutation first put forward by de Vries.

To return now to Haeckel, it should be noticed that, if he had been able to carry his main argument, he would have inflicted a fatal blow on the principle of natural selection. That principle supposes that in the organism certain variations occur ; these variations are either favourable or unfavourable to the organism in a certain environment in which it may be placed ; if the variation be favourable,

[1] This biogenetic law, it may be said, did not originate with Haeckel ; he appears to have derived it from K. von Baer, while in France it is referred to Geoffroy St. Hilaire and Antonio Serres ; but none of these pioneers explained the application of the law to suit the purposes of polemics as did Haeckel.

then the organism which has that advantage is more likely to survive than one in which it is lacking.[1]

But Haeckel's theory would tend to show that the development which has been spread over countless centuries, and brought about by innumerable changes of all kinds in the environment taken in a larger sense, may yet be reproduced regularly and very rapidly in an entirely different environment subject to comparatively few changes.

Now, if amongst the factors A, B, C, D, which tend to produce a result, A be changed or eliminated, then if the result follows nevertheless, the usual conclusion would be that A had little or no influence in the matter. When so expressed the matter seems fairly plain, but Haeckel, in his blind enthusiasm, was always prepared to override logical reasoning or even, as we have seen, facts themselves.

In other circumstances Haeckel, who was a noted free-thinker, might have become a fervid defender of the orthodox faith. As a matter of fact, while at one time he was a champion of all liberal ideas,

[1] A. Brachet, of the University of Brussels, has made a series of interesting experiments on Blastocytes (of the Rabbit) in which he has shown that considerable progress in development can be obtained in suitable media, away from the maternal uterus, even to the extent of the appearance of the organs of nutrition and of the organs necessary for the attachment to the uterus.

This would prove that, quite apart from the influence of the environment, there is at work a controlling system of forces which determines in main part the form the organism will take.

he became at the end of his life a fierce defender of militarism exemplified in all its beauty by the Hohenzollern régime. My admiration for his character is therefore eclectic, but even if it were greater it would not induce me to believe that bad arguments are sufficient to bolster up even good causes ; and his argument of the biogenetic law does not bear examination.

I will refer to Haeckel somewhat later but, in taking leave of him now, I would remark, though it gives me pain and even a certain discouragement, that the immense popularity which at one time he enjoyed was due less to his solid scientific work than to the more frothy quality of his philosophy. One asks : Will it be ever thus ? Must the old Roman aphorism become verified ?—Populus vult decipi ! (The crowd likes to be bamboozled.) For almost at every turn if the public have a choice between the truth presented in its natural colours and some showy sham of charlatanism, they flock to the spurious standard.

The Evolutionists have often laughed at the method of "Teleology" of the orthodox writers, that sort of approval of the Divine purpose which lauds the Creator for making the rivers run through the large towns ; but the doctrine of evolution has itself now become orthodox, and the teleological argument is there greatly in honour. It would be possible to cite hundreds of instances, but I select

one in especial, because it is adorned by names of real worth.

Grant Allen was certainly one of the most admirable men of science, of the second rank as he modestly claimed, whom we have possessed. He was a close observer of nature and the value of his research was enhanced by a charming style of expression. It is true that in the later years of his life he was forced by poverty and neglect to abandon his scientific work, and to write novels of a popular character, though even the success of *The Woman Who Did* did not console him for his lost studies.

Grant Allen was a Darwinist and in his book, *The Colour Sense; its Origin and Development*, he puts forward the theory that the taste for bright colours has been derived by man from his fruit-eating ancestors who acquired it by exercise of their sense of vision upon bright-coloured food-stuffs. This manner of arguing has facility, the fatal facility indeed of the practiced writer of ballads. I will not delay to deal with it point by point, for in an excellent little book called *Matter and Energy* Professor F. Soddy has pointed out that the greatest sensitiveness to colours corresponds to those parts of the spectrum where the light energy is highest.

Upon this fact one might trace out a course of evolution even more convincing than Grant Allen's but, in reality, no better based. Other observers

have pointed out that sensitiveness to light does not coincide with, or even run parallel to, clearness of vision ; but the question is involved in that of the function of the eye itself as an organ, and when we approach the problem in that way, we find it extraordinarily complex, and difficult of clear determinations.

Camille de Saint-Saëns has examined the eye of the snail, and he has come to the conclusion that it is used less for vision than for feeling. M. Edmond Perrier has studied the matter still more elaborately, tracing out the development of the eye from the lowest molluscs to those comparatively well-developed, and he has shown that though the separation between molluscs and vertebrates took place at a very low branching of the main stem, and though the eye, in the respective cases, has developed along a different course, yet the final results are similar.

On this subject Sir Ray Lankester is very instructive, for he has known how to combine great erudition with an admirable style of writing. He says, in speaking principally of vertebrates and molluscs in their various sub-divisions :

"The structure and history of the eye differs in each of these great groups, and it seems that it has developed independently in each great phylum, or line of descent, very simple, primitive eyes which were present in the early ancestral forms of each group. Thus, although the arrangement and structure of the elaborate eyes of the cuttle-fish and octopus, which are molluscs, are curiously

similar to those of the vertebrate eye, yet they have arisen independently in the molluscan line of descent, and again in the vertebrate line."

He then proceeds to deal with the snail's eye and points out that we can trace its line of formation from the study of the eye of the limpet, which is more rudimentary.

"Low down on the side of each tentacle is a little dark spot. When carefully examined this is found to be the eye. It is actually an open pit or sac—a pushing in of the surface cell-layer or 'epithelium' of the limpet's skin—and the cells within are elongated as light percipient retinal rods (photæsthetic cells), whilst behind them and at the sides of the sac is a lining of black pigment."

Later he deals with the vertebrate eye which, he says, differs widely in origin from that of the cuttle-fish, although the two are at first view so much alike.

"The simplest living vertebrates, the little fish-like lancelet and the Ascidian tadpole, are transparent, and have each a single black-pigmented eye, actually placed inside the hollow brain. In all the true craniate vertebrates the eye is formed by two hollow sacs or spherical vesicles, one which grows 'out' from and is part of the brain and forms the optic nerve and the retina, the other which grows 'in' as a pit or cup of the surface cell-layer of the skin, and forms the lens."

I have dwelt on this matter a little not only for its intrinsic interest, but also because it is a point of contact with M. Bergson, with whom we will deal later—not that I think Bergson's philosophy important, for it is really one of the least scientific of all, although it is externally decorated by a

wealth of scientific learning, and even though his spangly phrase, "Creative evolution," has caught the wayward fancy of George Bernard Shaw and induced him to think that in flashing it about he is uttering something philosophic and profound.

It was precisely this point of the eye of the cuttle-fish and the vertebrate that M. Bergson fastened on to exemplify his theory of the *élan vital*, but as Professor Callendar, in the Geology section of the British Association, remarked :

"Though the resemblance we have noted may be explained by the assumption that both creatures are descended, *longo intervallo* no doubt, from a common stock, and that the flesh or the germ of that stock had the internal impulse to produce this kind of eye some day when conditions should be favourable, it is not explained why many other eyed animals, which must also have descended from this remote stock, have developed eyes of a different kind. Nevertheless, I commend this hypothesis of Professor Bergson to the advocates of predisposition. To my mind it only shows that a philosopher may achieve distinction by a theory of evolution without a secure knowledge of biology."

Interesting as may be the account given by Sir Ray Lankester of the development of the eye, it does not lead us into some of the details which have been laboriously traced out by the great Spanish histologist, Ramon y Cajal, who found, in the case of the chameleon, that in the central area of the retina the cones become more delicate, and that each cone is connected with a separate tri-polar cell, and this again with a separate ganglion cell giving off an optic fibre ; and it has been remarked that

this development is correlated with a special motor adaptation which is of service in seizing prey.

The late Sir Frederick Mott has dealt with another aspect of this kind of co-ordination, for in the case of Felidæ he notes a specialization of the fore-limbs for prehension, which would be less effective for the purpose without stereoscopic vision. To thrash out all these arguments to their conclusions here would lead too far afield, but it may be said—and I only cite him for brevity—that Rochin-Duvigneaud concludes that results shown by Ramon y Cajal are not to be explained by the ordinary theory of natural selection.

A slight reservation should here be made, however, for it is astonishing what a little proof suffices for a Darwinian who is bravely determined not to yield an inch of territory.

Professor Bateson, as President of the British Association, quotes a delectable passage of a paper read to no less a body than the Royal Society itself, being in fact a Croonian Lecture on the "Origin of Mammals," and in which it will be observed with what frictionless speed a great philosopher can cover the ground :

"In Upper Triassic times the larger Cynodonts preyed upon the large Anomodont, *Kannemeyeria*, and carried on their existence so long as these Anomodonts survived, but died out with them about the end of the Trias or in Rhætic times. The small Cynodonts, having neither small Anomodonts nor small Cotylosaurs to feed on, were forced to hunt the very active long-limbed

Thecodonts. The greatly increased activity brought about that series of changes which formed the mammals—the flexible skin with hair, the four-chambered heart and warm blood, the loose jaw with teeth for mastication, an increased development of tactile sensation and a great increase of cerebrum. Not improbably the attacks of the newly evolved Cynodont or mammalian type brought about a corresponding evolution in the Pseudosuchian Thecodonts, which ultimately resulted in the formation of Dinosaurs and Birds."

Evolution while you wait, so to speak.

While in the vein I will quote one or two others of the great pundits of science, to show the character of the reasoning with which they are satisfied. Here is a passage from no less a person than Professor Schäfer. I take it from the *British Medical Journal* of 14th September, 1912, from the Paper: "The Origin of Life." One paragraph is headed: "Formation of the Nucleated Cell":

"The next important phase in the process of evolution would be the segregation and moulding of the diffused or irregularly aggregated nuclear matter into a definite nucleus around which all the chemical activity of the organism will in future be centred. Whether this change were due to a slow and gradual process of segregation or of the nature of a jump, such as Nature does occasionally make, the result would be the advancement of the living organism to the condition of a complete nucleated cell; a material advance not only in organization, but—still more important—in potentiality for future development. Life is now embodied in the cell, and every living being evolved from this will be either a cell or a cell aggregate, *Omnis cellula e cellulâ.*"

In another part of this paper, headed: "Part

Played by Nervous System in the Maintenance of Life: Evolution of a Nervous System," Professor Schäfer gives us this:

"Before we consider the manner in which the nervous system serves to co-ordinate the life of the cell aggregate, let us see how it has become evolved.

"The first step in the process was taken when certain of the cells of the external layer became specially sensitive to stimuli from outside, whether caused by mechanical impressions (tactile and auditory stimuli) or impressions of light and darkness (visual stimuli) or chemical impressions. The effects of such impressions were probably at first simply communicated to adjacent cells and spread from cell to cell throughout the mass. An advance was made when the more impressionable cells threw out branching feelers amongst the other cells of the organism. Such feelers would convey the effects of stimuli with greater rapidity and directness to distant parts. They may at first have been retractile, in this respect resembling the long pseudopodia of certain Rhizopoda. When they became fixed they would be potential nerve fibres and would represent the beginning of a nervous system. Even yet (as Ross Harrison has shown), in the course of development of nerve fibres, each fibre makes its first appearance as an amœboid cell process which is at first retractile, but gradually grows into the position it is eventually to occupy and in which it will become fixed."

Here again we have these thorny problems reduced to a delightful smoothness. The *élan vital* itself was left far behind by Professor Schäfer's gay capering through space and time, but I would ask any serious reader honestly to say, having read such elucidations, if he feels that on such a basis, or by aid of any principle enunciated or even adumbrated, he can build up the organic world?

My own feeling is like that of the little girl who read Browning. She surmised that it was pleasing, but she was in doubt as to which was the beginning and which was the end.

Let us, however, continue, and here it must be remembered that I am not selecting passages in order to provoke amusement from the scribblings of obscure or ignorant men ; I am quoting from the set works of the highest authorities delivered to the most competent audiences, and I assert that, as arguments either for or against Darwinism, they are devoid of value, and they only illustrate in how far orthodoxy can delude us as to the reality of things.

Professor Elliot Smith, who is another great light in the biological world, delivered the Cavendish Lecture on the 28th May, 1926 to a large and distinguished audience, and the Lecture was described, and no doubt rightly, as "fascinating" by one of his learned supporters. I have nothing to say on that aspect ; my criticism is simply that it was merely historically descriptive, that even on this ground it involved many unwarrantable assumptions both in Darwinism and Lamarckism, and that in regard to causative influences, even popularly shown, it has no meaning at all. It will not be unfair to him if I quote consecutively the major part of the report in the *British Medical Journal* :

" . . . . Certain creatures, however, like the jumping shrews of South Africa, had been able to avoid definite life, and their limbs did not undergo any degree of specialization but retained a primitive structure, with plasticity and adaptability to various purposes. One of these groups of shrew-like animals, as the result of an arboured existence, lost their dependence upon the sense of smell, while their sense of vision and their muscular agility were enhanced, so that while the brain of the ground shrew showed an enormous olfactory area, and above it a comparatively small territory concerned with visual, auditory and tactile impulses, the brain of a similar creature living in trees showed a great reduction in the size of the olfactory area and an enormous expansion of the rest of the brain. As this process continued there was brought into existence the order of primates, to which the lemur, the ape, and man belonged. In this order the significant change was the enormous increase in the visual territory of the brain. This was evident in the lowest creatures of this order—the lemurs and those lemuroid animals, the tarsiers. The tarsier, which still existed, a living fossil, in Borneo and Java, was almost identical in structure with a creature that existed before the beginning of the Tertiary period; it still retains many of the most primitive features of the earliest primates. In the tarsier, for the first time in mammals, vision replaced smell as the dominant sense. The main difference between the tarsier and the monkey was that the monkey had greatly extended the range and precision of the conjugate movements of the eyes, whereas the tarsier had not, but this latter creature had evidently felt the need for such a development, and had compensated for its lack by developing an astonishing range of head and neck movement such as no other mammal possessed. In all vertebrate animals other than mammals the eyes can move independently the one of the other, but in most mammals one eye could not be moved without the other being moved also. But the power to make conjugate movements of wide range and precision began with the monkey, and the lack of it held back the tarsier.

" In the monkeys and in man, when these delicate movements were made possible by the special development of the cortex, the

macula lutea developed, and the animal thus gained the power of discerning the details of objects, of practising a nicer discrimination between colours and textures, of distinguishing between objects of similar shape which to an animal without a macula was impossible. All this had a profound influence in stimulating the development of the cerebral cortex. The animal had its curiosity excited so that it handled and examined objects, cultivating also in this way its power of skilled movement, guiding its hands with amazing dexterity; its auditory and vocal powers and its tactile capacity also increased, and all this again expressed itself in the structure of the brain, which showed a great frontal expansion. By comparing the lemur or the tarsier with the marmoset it could be seen that the enhancement of muscular skill was acquired at the time that the power of stereoscopic vision originated.

"From all this (Professor Elliot Smith continued) it was possible to build up a theory or hypothesis to explain how the high powers of discrimination began. The cultivation of vision started a cycle of further changes, which themselves led to still other changes, all in the direction of greater power and refinement. There was reason to believe that the development of the prefrontal area, which grew out, so to speak, from the motor territory, was itself an expression of the increased powers of skilled movement. In the course of this evolution it became possible to apply these increased powers automatically, so that the animal was able to concentrate its vision upon things seen rather than upon the motor act of seeing. When an animal learned to converge its eyes upon a particular object it was also fixing its attention and acquiring the ability to concentrate the mind for a particular purpose. The lecturer added that when one came to the fossil remains of man one found still other stages in the development of the pre-frontal and parietal areas. These regions were smallest in the Pithecanthropus of Java, considerably bigger in the Piltdown man, bigger still in the Rhodesian man, and showed further progress in Neanderthal man. The brain continued this progressive expansion until it reached the more equable stage of development in *Homo sapiens*. Man's mental superiority was really based upon the seeing eye and the dexterous hand."

All this, I grant, is "fascinating," as the chairman said, but judged by the standards of a veritable scientific exposition it is little better than the account given by Molière's doctor—there is a similar assumption that technical terms make an explanation ; a similar rapid course over apparent facts, and a similar impressive conclusion : "And that's why your daughter is dumb" !

So far, although we are not sensibly advanced in the understanding of evolution we have been, at any rate, on more or less solid ground. Let us now see how one of the great philosophers tackles the question. I am obliged to quote at some length, for the amount of matter to the cubic metre—what one might call the density of the thought—is small. The author is Professor Lloyd Morgan, F.R.S., President of the Section of Psychology of the British Association :

"What do I mean by 'Emergent Evolution'? Shall we start from the platform of that which we call common-sense as tempered by the refinement of scientific thought? By general consent we live in a world in which there seems to be an orderly passage of events. That orderly passage of events, in so far as something new comes on to the scene of nature, is what I here mean by evolution. If nothing really new emerges—if there be only permutations of what was pre-existent (permutations predictable in advance by some Laplacian calculator)—then, so far, there is no evolution, though there may be progress through survival and spread on the one hand and elimination on the other. Under nature is to be included the plan, expressive of natural law, on which all events (including mental events) run their course.

"From the point of view of a philosophy based on science our

aim is to interpret the natural plan of evolution, and this is to be loyally accepted just as we find it. The most resolute modern attempt to interpret evolution from this point of view is that of Professor S. Alexander in his '*Space, Time, and Deity*.' He starts from the world of common-sense and science as it seems to be given for thought to interpret. In order to get at the very foundation of nature he bids us think out of it all that can possibly be excluded short of the utter annihilation of events. That gives us a world of ultimate or basal events in purely spatial and temporal relations. This he calls 'space-time,' inseparably hyphened throughout Nature. From this is evolved matter, with its primary and, at a later stage of development, its secondary qualities. Here new relations, other than those which are only spatio-temporal, supervene. Later in logical and historical sequence comes life, a new quality of certain systems of matter in motion, involving or expressing new relations thus far not in being. Then within this organic matrix, already 'qualitied' (as he says) by life, there arises the quality of consciousness, the highest that we know."

So far, this appears to me to be little different from the old mediæval nonsense, but let us continue in deference to the high position which Professor Lloyd Morgan has occupied, and the importance of the occasion on which he spoke.

Here we find him coming to grips with the subject :

"The concept of emergence is dealt with by J. S. Mill, in his *Logic*, under the consideration of 'heteropathic laws.' The word 'emergent,' as contrasted with 'resultant,' was suggested by G. H. Lewes in his '*Problems of Life and Mind*.' When oxygen, having certain properties, combines with hydrogen having other properties, there is formed water, some of the properties of which are quite different. The weight of the compound is an additive *resultant*, and can be calculated before the event. Sundry other properties are constitutive *emergents*, which could not be predicted

in advance of any existent example of combination. Of course, when we have learnt what happens in 'this' particular instance under 'these' circumstances, we can predict what will happen in 'that' like instance under similar circumstances. We have learnt something of the natural plan of evolution. We may also predict on the basis of analogy as we learn to grasp more adequately the natural order or plan of events. But could we predict what will happen prior to *any* given instance—i.e., prior to the development of this stage of the evolutionary plan? Could we predict life from the plane of the inorganic, or consciousness from the plane of life? In accordance with the principles of emergent evolution we could not do so. The Laplacian calculator is here out of court."

Let us still hope, and give Professor Lloyd Morgan a further chance.

"For M. Bergson the philosophical question is: What makes emergents emerge? Rightly or wrongly, I do not regard this question as one with which science, as such, is concerned; and in some passages at any rate this is the opinion of M. Bergson himself. Philosophy, he says, ought to follow and supplement science, 'in order to superpose on scientific truth a knowledge of another kind, which may be called metaphysical.' Be that as it may, his answer to the question: What makes emergents emerge? is Mind or Spirit as Vital Impulsion. (I use capital letters for concepts of this order). Whereas, then, for Mr. Alexander mind as consciousness is an empirical quality emergent in nature at an assignable stage of evolution, for M. Bergson Mind, as Spirit, is the metempirical Source (I adopt Lewes's adjective) through the Agency of which emergent evolution has empirical being. For the one consciousness is the product of Spiritual Activity, which is sometimes spoken of as Consciousness. The methods of approach, the treatment, and the conclusions reached, are different. Although my present concern is with the former, this must not be taken to imply a denial of Spiritual Activity. Its discussion, however, belongs to a different universe of discourse."

Here is a passage after the Professor has consumed several pages, and where he might be supposed at length to have got well into his stride —I beg his pardon—where he may be soaring in unimpeded flight !

"Mr. Alexander emphasizes the distinction between what I have called the *-ing* and the *-ed* in the most drastic manner. He speaks of all that is in any way objective to minding as non-mental. I cannot follow his lead in this matter, because I need the word in what is for me (but not for him) a different sense. But what does he mean ? It is pretty obvious that while seeing is a mental process in which I am conscious, the lamp that I see is not a mental process, but an object of which I am conscious. If, however, I picture the Corcovado beyond the waters of Rio Bay, is that mental ? The picturing of a remembered scene is a mental process ; but that which is thus pictured is not mental in the same sense. It is just as much re-presented for the remembering as the lamp is presented as an object for the seeing. And suppose I try to think of the four-dimensional space-time framework conceived by Minkowski ; the thinking is unquestionably mental, but the framework thought of is not mental in the same sense. What is not mental in that sense Mr. Alexander calls 'non-mental.' I speak of that which is not mental in this sense as 'objective.'"

If any reader has made much of these passages, or if he find in them a stimulus sufficient to induce him to go to the original—which he will find in the Report of the British Association for the year 1921, in full,—then I doff my cap to him with the humble acknowledgment that he exercises faculties which I do not possess. I will make a further confession. When I read the passage, and again and again forced my weakened spirit to the ascent :

"What makes emergents emerge?" I found that like opium it produced slumber because of its "dormitive effect"; and in that slumber I heard another question, equally important, equally insistent, equally insoluble: "Did you ever see a winkle wink? . . . . Then why call it a winkle?" Then I awoke with a start in a world far from Lloyd Morganism or Bergsonism, the world of reality.

Observe that this Discourse was delivered in Edinburgh, the habitation of a hard-headed race, noted for shrewd common-sense—it was they, in fact, who produced the Common Sense school—and one can form some faint idea of the hypnotic influence which the Middle Ages—was I not right to say that they are still with us?—can extend upon the human mind.

Then comes the saddening reflection, that it is upon minds so over-loaded with false learning, so devastated by metaphysical nonsense, that any new work, no matter of what originality and power, must make its impress before it can break through that ring of professors, those authorities of the British Association which constitutes, in these subjects at least, the gravest obstacle to intellectual advance.

But let us return to our sheep, and to the company of one who, although I believe he was mistaken in his main thesis, yet went far to justify himself by real thinking and serious observation.

Weismann's argument, when stripped of the thousand details by which he gave it support, amounted to this: That the somatic cells—those which are concerned in the development of the tissues of the body—and the germ cells, concerned solely in reproduction, derive from different sources, and that the development of the body has no influence upon the germ cells. There is no mechanism present by which such influence could be manifested. Therefore Lamarck's theory falls to the ground.

Weismann developed his own thesis with extraordinary assiduity, but he had no right to assume that, because he had not discovered the connection between the somatic tissues and the germ cells, this might not possibly exist. We have already seen examples which prove, as a matter of result, that acquired faculties may be transmitted; but beyond these there is the evidence also of the hereditary transmission of the effects of certain poisons. The Weismannian cries out: "Yes,—but those are not transmission of faculties!" Be that as it may these facts indicate that it is possible for the body to influence the germ cells even profoundly.

Weismann himself built up an elaborate system of "determinants," "ids," and "idants" and other factors in as thorough a fashion as a Prussian officer regulating a garrison town; but he did not clearly demonstrate the respective functions and the play of the mechanism so indicated.

His theory is a variant of that of Preformation of old with the additional notion of the " Emboîtment " of Becher. If it be true it would present the development of the race so determined that the striving for any moral or intellectual superiority would be greatly diminished in value, on account of not being transmissible. This should not deter us from accepting it, if only the theory be true ; but it is not true.

Herbert Spencer was the most noted opponent of Weismannism, but though I accept his conclusions for the main part, I do not find his arguments conclusive. Herbert Spencer was unduly biased in favour of Lamarck, and he was insufficiently acquainted with biological processes. Nevertheless, he had a great influence on the history of the theory, and to him is due the striking phrase, the " Survival of the Fittest," which has been already mentioned, and which appears to me to be meaningless.[1]

Darwin, it should be mentioned, was equally troubled with Weismann to find some sort of mechanism by which new characters could emerge from the germ cells in their course from generation to generation. He imagined that each of the several tissues, in fact each element of the tissues, gave off

[1] When a strong organism is replaced by a feebler one; the Spencerians say, yes, but the feeble organism was really the fittest. The test is survival. Ergo: These organisms survive which do survive.

minute bodies, "gemmules," which eventually found a habitation in the germ cell. These gemmules were never demonstrated, and their mode of functioning was never clearly explained, so that they represented little more than the recognition by Darwin of the need of some mechanism.

Both the Darwinians and Weismannists asserted in regard to their respective doctrines that no other explanation could be conceived. This reminds one of the old fallacious argument of the "Sufficient Reason." The Darwinians spoke of the variations as arising spontaneously, but the more we penetrate into the mysteries of the bodily functions, the less room we find for spontaneous appearances. The words "sufficient reason" and "spontaneous" here were simply covers for our ignorance, but I notice that a distinguished biologist has contrived to combine in one sentence both the faulty methods indicated. Dr. Archdall Reid, discoursing on "Methods of Research," in the *British Medical Journal* of 28th October, 1912, says:

> "The hypothesis that variations were normally spontaneous was the only relevant hypothesis which was compatible with the law of Evolution through natural selection."

Those who begin to study the doctrine of Evolution are apt to be carried away too readily by the evidence that variations are abundantly demonstrated, but it is well to have in mind a warning such as supplied by an image that M. Yves Delage,

famous for his experiments in Parthenogenesis, once brought to my mind. He said that if a ball be suspended from the ceiling by a great number of elastic threads it is easy to move it from side to side, but as the movement proceeds it does not become more facile; on the contrary, we reach a point where it requires a very great effort to produce any further movement at all. "So it is," he said, "with variation in living organisms."

Then, after a pause, during which he was plunged in deep thought, he looked up and said: "The more I study the matter, the more baffled I am. *C'est à devenir fou.*" (It is enough to make one mad!)

The latest great authority to pronounce upon the theory of Evolution was Professor H. F. Osborn, the President of the American Museum of Natural History, who spoke before a crowded assembly of the Meeting of the British Association in Oxford.

He said that we were entering upon an entirely new era of research on the problem of the origin of species, and it was marked by the decline and death of the chief speculations based on the knowledge available in Darwin's time. He said that the new knowledge confirmed Weismann's sharp distinction between bodily adaptations to environment and germinal specific characters. Species do not originate by inheritance of acquired characters, or by the survival of fortuitous variations.

Professor Osborn, however, in the course of his

Address, showed how species were still in process of formation, the factors being geographical isolation with enforced physical or chemical change, enforced change of habit, enforced competition with new environment, and new stimulus to the germinal energies themselves, though he made it clear that the manner in which this complex of forces acted on the germ plasm to produce adaptive results was not known.

This part of his Address seems to admit the operation of Lamarckian factors, as well as Natural Selection, although he rightly makes the process much more complex and gradual than had been assumed.

At this stage, then, we may briefly indicate conclusions attained :

Lamarck : Theory true, but much more limited than Lamarck thought, and slow in operation.

Darwin : Theory true within its scope, but insufficient to explain.

Weismann : Main conclusions not true, but thesis useful as corrective to loose work.

De Vries : Evidence good, but under examination as to causes.

Mendel : Valuable results, but formal, not causative.

Nägele : View justified, but not sufficiently definite.

The question therefore enters, as Osborn has

indicated, upon a new phase. There is one aspect which, it seems to me, has not been sufficiently studied, and that is, not the influence of the environment on the organism, but the adaptation to its purposes by the organism of the constituents of the environment.

Galen of old said :

> "Take three eggs, one of an eagle, another of a goose, and a third of a viper. . . . The eagle will soar to the highest regions of the air, the goose will betake itself to the marshy pool, and the viper will bury itself in the ground."

Here we are in presence of factors enormously more potent than that of change in environment. When we look more deeply into this question of adaptation of environment, we find that it opens a new vista. Two examples may be given out of thousands that are to be found, of an adaptation not produced by the environment, but tending towards its utilization. In mammals the temperature of the blood is in great part independent of the external temperature ; in some of the lower forms of life it is dependent on the temperature. Here then, the mechanism which produced the difference, cannot be said to be the product of the environment.

Again, there is a reponse to the action of microbes in the body, a defensive force being formed by the production of anti-bodies. Now an organism may have been brought to a high state of development, independent of any contact with certain forms of

microbes; when these microbes are introduced at a given stage they become dealt with and eliminated. It may be possible to trace at some anterior stage of development the origin and growth of functions tending to the result indicated, but it would only be a straining of language to say that these functions were produced by the environment.

To put the matter for brevity into an image, I would say that the environment is not a drill-sergeant, but a commissariat officer; it helps developments in certain directions rather than determines them.

What then are the forces tending to definite development? Here inevitably we come to something contained in the germ cells of the organism, but it is not necessary to suppose either the array of gemmules of Darwin or the ids and idants of Weismann; it is possible that an organism may proceed towards a development which is, in a sense and under certain conditions, predetermined, without the necessity of supposing that the organism at a given moment contains even the germs of the tissues or the functions which it may afterwards acquire. It develops by virtue of what, for the sake of brevity, I will call an "organic function." This term I will proceed to explain.

Those who are familiar with mathematics will know that the development of a figure may be expressed by means of a formula, or function, in such

a way that if the figure, say a logarithmic spiral, be successively described, the formula will be sufficient to determine its form up to any point desired.

That is a bare figure, but consider next a complex dynamical system held together by all sorts of mutual connections. If now a new force be introduced into this system, it will have its due effect, but that effect may not be such as perceptibly to change the constitution or movements of the system.

If, for instance, we throw a stone into the air, we alter the centre of gravity of our terrestrial system, but without this result being perceptible.

Now there is a principle in science called the law of Le Chatelier, which might be expressed by saying that the tendency is to reduce to a minimum the effect of new forces introduced into a system.

This is a sweeping generalization, and it obviously involves many assumptions but, on the other hand, it has a wide range of applications that may be verified. I cite it here only for convenience of brevity.

If now we proceed to further complexity, and we conceive not a lifeless dynamic system, but a living organism containing within itself a great series of dynamic systems, of which the laws of movement may be finally entirely physical; then imagine this system brought into a certain environment; that is to say, imagine it played upon not merely by new forces brought in from the outside, but also interacting upon the environment itself,

transmuting these forces and adapting them ; then we will begin to see that forces such as Lamarckian forces may have due influence upon the constitution and movements of this organism, and yet, bearing in mind the law of Le Chatelier, may be rendered inappreciable in their result till, after the lapse of a long period, during which such forces have been operating, their effects have become integrated into an amount that produces definite and perceptible changes.

We must now regard the environment, even for the play of natural selection, as something more complex than indicated in the first descriptions of its operation given by the Darwinists ; as, for instance, in the story the whiteness of the snow bringing about the whiteness of the Polar bear. The environment must be regarded not merely as possessing qualities that immediately strike the sense, but as containing masses and forces which play on the varied and complex physiological functions of the organism. And finally, we must always bear in mind those processes of adaptation to the environment that might be perhaps as well described as adaptation of the environment.[1]

[1] When in a system of forces a new force is introduced, a modification of the whole system follows ; we get what is called the resultant of all the forces. When we consider diverse associated systems and new forces added in any form of distribution we may conceive, each of these systems becomes modified to a new resultant, and the whole association becomes modified accordingly. Now in

Could we even in this enlarged view work out a complete scheme of evolution? I think not. It is necessary to ask the question, which raises delicate and profound issues: What is there behind the "organic function" that brings it into being and makes its vital formula active?

Here again to clinch the matter briefly, I say that we seem to be forced to find, behind all this mechanism, a deeply conceived design or purpose, and if I be asked whether that implies Mind, I answer, "Yes."

It is with reluctance that I find myself constrained to use the word "design," because it has implications of the old teleology of Paley and others of that school, in which illustrations that should be regarded scientifically are mixed up with all sorts of associations and prejudice-bearing influences. Paley, I am convinced, got most of his

the extraordinarily complex play of forces of the human organism, impinged on by new forces from without, there is at every moment a new resultant in the particular systems of forces into which the forces included in the whole organism could be analysed, but also there is a new resultant expression of the whole organism. That resultant, again, at each instant deals with the external forces, modifying that part of the environment which tends to produce contact with the organism; it is this incessant interplay, from instant to instant, of the organism with the external world, that, in as far as material phenomena are concerned, constitutes the life of the organism. The representation, therefore, of the "organic function" or formula rises in difficulty with each stage of development of the organism, but the original conception still serves as a guide.

ideas from Sir Charles Bell, whose interesting work on the Hand brought the question to the fore and who gave to the theologian whatever was valuable in his descriptions.

But I wish to enlarge the scope beyond such illustrations. We have already met with many examples such as that of the development of the eye and the parts subservient to prehension, which are inexplicable on any other theory than that of a purposive development. We get a more impressive view still when, on the one hand, we endeavour to trace out the enormous complexity of the single cell itself, and then proceed to a particular study of the chromosome of the nucleus of the cell, where in this minute form we have a wonderful play of myriad forces in the infinitely small world, which yet contain the potency of vast developments. When, then, we see how carefully adjusted must be the concurrence of forces to produce here any determined change, and when from that we raise our eyes not merely to the development of species but to the separation of orders and kingdoms, each elaborating into wonderful forms of life, then more and more we seem to find something of a wonderfully conceived purpose, even more convincingly than what we call purpose in our human lives.

The matter seems to me presented as definitely as if an artificer were at work with the task before him of producing machines by the employment of

a limited number of components. Looked at in this light the arrangement of the human body itself is marvellous.[1]

I remember once reading in a casual letter to myself from Sir William Gowers the expression, which struck me at the time and made me return again and again to ponder : " The wonder of the knee-joint."

In the human frame the locomotive part of the apparatus depends almost entirely on a system of levers, the motive power being contained in the muscles activated by the nerves, the nerves themselves being stimulated ultimately from external sources. One would almost imagine—if I can say so without being misunderstood by too serious people—that the Divine Architect had been reading Galileo and, having admired his analysis by which he reduces mechanical engines to their elements, had proceeded to show what He could do by levers, inclined planes and strings. The wheel is not included in our human mechanism but, astonishingly,

[1] I remember once having read, although I cannot now put my finger on the reference, that a friend of Darwin once asked him : Do you think there is a ' Mind ' behind all that ? Darwin looked up, and gazed intently on his friend with an expression which, in its strangeness and abstraction, seemed to show that the question had struck upon deep preoccupations of the biologist's mind. He seemed lost for a time in thought, but he did not reply to the question. That same preoccupation and sense of searching would no doubt be found with all the serious thinkers and earnest students of nature.

we find it in the lower world, in the rotifers, and we find also the screw.

The pulley is in use, and subserves the play of the tendons and, marvellously enough, in one of the muscles of the eye, we see an arrangement which indicates to us how the pulley action might have been developed. The superior obliquus has to exercise, by its contraction, an action not in a line with its extreme attachments. It therefore became hitched on at one point to a piece of cartilage, and thence became continued to the other end ; in process of time, and by the effect of use, the cartilage acquired the pulley form round which, invested with a membranous sheath, the tendon of the muscle slipped.

All this, it may be said, is due to mere chance, or to "spontaneous" variations, or to the play of that blessed word "environment." To me all that seems puerile.

It is true that we have a great number of forces at our disposition in the aforesaid environment, but it is also true that, at every one of the innumerable changes, any disturbance of co-ordinated laws would destroy the entire mechanism. We require, therefore, a consensus of an infinity of infinity of chances to produce the results we see.

Finally, it might be said, that what we call law is something purely subjective. There is some value in that remark, and in an earlier part of the book, I

have shown that what are called Laws of Nature mean only the explanations that we adopt in order to make phenomena simpler in our own conceptions.

That is true ; but further it is true that there is something more profound underlying that conception again.

The saying of Plato that "God geometrises" is an expression of a truth that develops more and more marvellously as we have wider and deeper visions of the functions of nature. And there is, beneath our own conceptions of law, the indestructible fact that certain harmonies become revealed to us, showing the operation of simple principles that are yet displayed in myriad and apparently complex forms ; and it is also true that in those cases where we have not discovered the law, we are led on in our research by the conception of forms of simplicity and symmetry which yet may be found displayed in harmonious movements ; so that even if we attempt to reject the idea, we still tacitly accept it, that we find the operation of law, of purpose, and the intuition and evidence of Mind.

Finally, to come down to earth again, we may still seek for the instruments and the direction of these varied developments ; that in turn leads us to assess, as far as we can, the factors we have already seen, of Lamarckism and Darwinism, and to search for others that as yet we wot not of—the meaning of the "organic function" which produces evolution.

CHAPTER EIGHT

PHYSIOLOGY

PHYSIOLOGY in its modern form is one of the most recent of the sciences. Considering how important it is, not only from the philosophic side but in regard to material questions of health and physical development, it is surprising that during the centuries it should have suffered so much neglect, but the history of science to some extent explains this anomaly.

We have seen already how strong was the grip of the Church on all matters relating to research and education, and physiology from an early time fell under deep suspicion as a dangerous and even illicit science. Yet in the early days of our modern world, dating from Galileo, considerable research in physiology was carried out by some of the learned monks, notably by Fallopius, in whose honour the Fallopian tubes bear his name. His researches were closely watched and kept under control by the Inquisition.

Eustachius was still more energetic and fortunate in his research than Fallopius, and though he too has a tube to preserve his name, his fame was somewhat obscured in his own day.

His drawings were impounded by the ecclesiastical authorities, and locked up in a cupboard in the Vatican where they remained hidden for one hundred and fifty years. When at length they were discovered and published it was found that our knowledge had just about reached the point at which Eustachius had left it. The effect, therefore, of the action of the Inquisition was to withhold this enlightenment from mankind during six generations of thinking men.[1]

In the old days it was the fate of the physiologists to discover with fear and trembling, for the wider their knowledge the more precarious became their hold of happiness in this life. One of the most poignant stories in history is that of Vesalius, the father of anatomy. His fame became wide in Europe, and on one occasion he was called in by Philip II of Spain to attend to his son, Don Carlos, who appears to have been what we call nowadays a wastrel, but who serves nevertheless as a romantic figure in story.

One day in Madrid Don Carlos, seeing a pretty young girl pass, launched into pursuit. The girl fled and turned down a side-street and Don Carlos,

[1] Eustachius himself was not persecuted, for he was physician to the Cardinal Duke Borromeo, but he had to be circumspect in his judgments. It may have been something of this sort that induced him to defend Galen against Vesalius, though nowadays everyone recognizes that Galen's work is packed with error, whereas Vesalius was careful to rely upon accurate observation.

giving hot chase, slipped on a cobblestone, fell backwards and cracked his skull. The prince lay there for some days unconscious, and all the orthodox remedies, including prayer offerings throughout the kingdom, proved unavailing ; and then in despair, the king called in Vesalius.

The great anatomist did not take long to see what was the cause of the mischief—a portion of the skull bone was pressing on the boy's brain. He therefore declared that he thought he could help the prince, but he was not allowed to begin work until certain relics—the bones of two holy monks—had been brought, and laid upon the bed. Vesalius trepanned the skull and lifted the bone and Don Carlos soon revived. There were great rejoicings of course, and Vesalius would have been greatly honoured had he been entirely orthodox. His assistant, however, made the incautious remark that the recovery of the prince was due rather to the skilful measures taken by his master than to the presence of the holy bones. To make a long story short, Vesalius and his assistant had to fly from Spain. The boat which carried them away from its shores was wrecked on a small island, and the imprudent anatomist died there of hunger.[1]

[1] Such, in brief, is the account which I have seen given from authoritative scientific sources of the fate of Vesalius, but we must not rely upon error, even when it seems to help our general cause.

Looking more closely into the matter I have found that Philip really protected Vesalius at his Court, but the great anatomist was

I cite this as a little parable, because Vesalius in this story seems to represent science itself. It is little respected for its own work in general, but the scientist is esteemed for the service he can render. Science is honoured if it consents to be subservient to the orthodoxy of the day. If not, it becomes an object of persecution. That same history is repeated in a thousand forms, and it is as true in our day as it was in that of Vesalius.

In the Bibliothèque Nationale in Paris may be seen, under a glass case, a book which is unique. It is the one copy left of the work of Servetus, who was burnt by Calvin at Geneva, not certainly for having written this particular book, but for holding opinions which were part and parcel of the philosophy that induced him to write the book. It is opened at a page where one can read a summary account of the circulation of the blood. This was years, of course, before the date of Harvey, who was physician to Charles I, but I do not wish on

unsparing in his raillery against the monks. They were not content to reply directly to his charges and sarcasms, but they heated up the feeling of the populace and, finally, they brought an accusation against him of having dissected a living human body. It was on this account that he had to fly from Madrid, for Philip, in order to save him from execution, suggested instead a penitential pilgrimage to Jerusalem, and it was while on this expedition that Vesalius was wrecked on the island of Zante, off the western shore of Greece, and where, according to some, he perished of hunger, but according to others, and more probably, as a result of the hardships he had undergone.

that account to diminish the lustre of the great Englishman's discovery.

Servetus had but a rudimentary and, in part, faulty notion of the circulation of the blood, but Harvey demonstrated the matter by a series of difficult experiments and observations. Although these demonstrations still remain as the best we know in this domain, they did not convince Harvey's contemporaries, except those, of course, including the King, who took the extraordinary course of examining his proofs before denouncing them. Harvey was a practising physician at the time and his practice went down by a half as a consequence of the publication of his researches. The Royal Society at first looked askance on his work, and no doubt would have anathematized it had not Charles II, who was a remarkably enlightened man in some respects, shown it indulgence.

This same Royal Society, by the way, at that time and since, has been capable of almost incredible vagaries. One of the papers which it gravely printed asserted that the east wind was a cause of pregnancy and, on the strength of this theory, suggested precautionary measures during its prevalence. This reads like sheer insanity but, in a different form, I could find its parallel to-day ; it is true the parallel would not be accepted as absurd, but I would point out for the moment that neither was this theory accepted as absurd at the time it was propounded,

otherwise the Royal Society would not have admitted it.

The root of all these aberrations is the same ; the learning which has been transmitted to us from the Dark Ages when the great Schoolmen, the Royal Society of the day, reigned supreme.

To return to Harvey : His theories have been probably only too completely accepted, and in University textbooks from generation to generation his theory of the circulation of the blood has been taken as complete without further examination. It would, however, lead to considerable difficulties if it were traced out step by step in all its consequences. If the arteries are really tubes through which the blood is propelled as by a force pump, then since which the height to which a body is projected upwards varies at the square of the initial velocity, the blood of a tall man, requiring a much greater vertical ascent from the heart, would necessarily possess a much higher initial velocity, and the character of the pulse would be different to that of a short man ; this, however, is not found to be the case. The explanation, I think, is that the great arteries are themselves a kind of prolongation of the heart and that the propulsive action is carried on successively right throughout their length. Lately I have seen this suggestion taken up by a Continental research worker, but I cite it now to show how the great teaching schools of the world,

so extraordinarily strict in respect to some points of teaching, are content to accept explanations which are either faulty or which have never been properly demonstrated. They have become articles of faith.[1]

In nearly all Universities and Medical Schools certain theories, by dint of being repeated, acquire the sanctity of the Thirty-nine Articles, and in order to question them, or even to offer criticisms which seem forced by the facts themselves, there is required something more and something rarer than clear intellectual vision; that is to say, a certain quality of intellectual honest and naïve courage. Everything in the orthodox school tends to conformity, and if one swims with the current all is well; if not, then everything is contrary. I remember once asking one of my teachers for some explanation of an apparent paradox, and his reply was: "Oh, never mind that! You drink in all that I tell you, and when the examiner comes round, spit it out!"

In these words was contained a great amount of practical wisdom, much more useful in regard to success, whether in the academies or the outer world, than that somewhat pernicketty and odious quality indicated as respect for truth.

One of the great fetishes in the medical world is that of the localization of aphasia. Broca, a cele-

[1] As this book is passing through press I notice some excellent new work on this subject by MM. Linche and Fontaine of Strasbourg.

brated physiologist, after examining clinically and then by post-mortem research, a great number of cases of aphasia, found that they were always associated with a lesion of the third convolution of the left frontal lobe of the brain. About the time that he made this discovery localization had become a fashionable pursuit. Localization was going to do for us what metaphysics, the philosopher's stone, and mathematics had in turn been expected to do; that is to say, reveal to us once and for all the inner secret of things. Localization had first of all contented itself with external signs, and Gall and Spurzheim had gained renown, which still persists, by finding significance in the conformation and external marks of the skull. From their researches sprang the great science of "feeling the bumps." That I think is as popular as ever, although the theories of the professors have been too crude for anything but practical use. They label a bump with a name which really comprises half a dozen different faculties, and they show no real connection between this conformation and the character proclaimed by the label.

Gall was a serious scientific man, who occupied himself with valuable research, and who had a great acquaintance with the functions of the brain and the development of the skull, and in our own time Dr. Bernard Hollander has defended the cause, and

make it as free from reproach as possible in the light of our present knowledge. I do not accept his reasoning, because I believe that the whole problem should be expressed in quite another manner.

Aphasia means the inability to utter words coherently, with a sense of their meaning. The matter therefore seems much simplified by supposing that a sort of faculty for words resides in Broca's convolution, so that, if the convolution be injured, the faculty becomes impaired. In place of labelling a "bump" Memory or Eloquence we tick off Broca's Convolution as "Word Faculty," and then we proceed to the next triumph.

But words themselves, although we are so familiar with them as not to notice it, are very complex things. In the first place the appearance of the written word is not at all simple. It involves visual effects and a certain co-ordination of the sense of effort involved in locomotion. But this form has no meaning unless it be associated with the sound, and unless the sound again be associated with the visual, auditory, and tactual impressions involved in the full meaning of the word. Now the development of the brain has been carried on independently of the development of any special language; and from that fact alone it must follow that, so far from a complex product such as a word corresponding to a definite part of the brain, every element into which the word can be analysed must

have some representation in the brain; and as, by the theory of localization itself, these visual, auditory, tactual and other centres are separated, and as their co-ordination is required for the understanding of the word, it is evident again that not only must each one of these centres be concerned, but also the lines of intercommunication between them.

The matter is far more complex than here represented, for when the analysis be pushed to extreme limits, that question of co-ordination would seem to be of great complexity; but without going further in this direction we have already a conception of activities in the brain, concerned in the recognition of a word, very different from that of localization. Instead of a man sitting in a cabin, giving out a word or denying it, according to his state of health, we have the vision rather of an elaborate system of electric lines branching off from various stations and arranging their messages according to a system that varies with each word.

Not only that, but the brain itself is not like a piano, to be played upon; but, to use the image of Sir William Gowers, rather like an organ containing pent-up energy which our stimulus does not create, but releases. For the full comprehension, therefore, of even two words in sequence we must regard not only the active factors, but also the inhibitory process. If, therefore, our knowledge were sufficiently extensive and our instruments

delicate enough, we could produce any form of aphasia, not by violently injuring Broca's convolution, but by cutting delicate strands of nerves at certain places here and there, according to our system, so as to destroy the co-ordination required.

This question of the so-called localization of aphasia is of interest to me, for it was on lines of an analysis, founded again on a still deeper analysis which affords the base of a System of Psychology which I have published, that I concluded that the usual teaching with regard to aphasia was so far away from the mark that it could hardly be said to be right or wrong,—it simply referred to a false conception. These views are not now regarded as chimerical, or up in the air, for Marie, in Paris, working for many years in the same hospital as Broca before him, but with a greater number of cases, with some of them more clearly defined, finally reached the conclusion that Broca's view was not justified. The results were set forth in two big volumes by Dr. Mouthier, and, in summing up, Marie gave a psychological expression embracing the facts; though this was not complete, I wish especially to note, in regard to the clear comprehension of the ultimate analysis required.

In spite of all this, however, the Medical Schools continue to teach the old theory of Broca's convolution, and distinguished surgeons triumphantly point out that, in cases of aphasia, they do, as a rule,

find damage in the third left convolution. This simply means, of course, that in the elaborate system of communicating fibres required for the expression of words, strands may be collected closer together in Broca's regions ; but all that is a very different affair to what is understood by "localization."

Monakow is the histologist who has worked most elaborately and intelligently in this domain, and he concludes, though for quite other reasons, against the notion of localization ; and he expresses the matter picturesquely by saying that the centres usually pointed out are not dwelling-houses, but gates through which the lines of transmission pass.

Broca's Convolution will, however, hold its own for many a year, just as, previously to these late world-shaking days of revolution, Chinese mandarins attached essential importance to the study of archaic literature which meant nothing in particular. It was not a training in the art of governing provinces, but it served as a mark of recognition of the mandarins amongst themselves, and gave them the necessary centre of cohesion.

The preceding remarks will find some application in a sphere apparently little related to what we have discussed. It is only in comparatively recent times that people have begun to investigate the processes of the senses, such as we usually recognize —sight, hearing, touch, etc.

In the year 1816 Charles Bell, to whom we owe the fundamental distinction between sensory and motor nerves, suggested that there are in the inner ear a series of minute cords which might react to the waves of sound in the manner in which the strings of a harp respond to their respective notes. Johannes Müller, the great German physiologist, had a similar notion, but it was not until Helmholtz enunciated his theory, in 1863, that much attention was given to these suggestions.

In the inner ear there is a peculiar structure called the organ of Corti, after an Italian anatomist who investigated it. The organ of Corti may be described as a series of minute strutted rods which in sequence form a kind of tunnel, arranged along the basilar membrane in the cochlæa, a structure of a shape somewhat like a snail's shell, which, by a series of arrangements, all very wonderful, and still not quite understood, becomes connected with the drum of the outer ear. The basilar membrane and organ of Corti are associated with nerve filaments which are eventually connected together, and which traced backwards terminate in the brain.

When the basilar membrane is dissected out and well displayed, the suggestion naturally arises of a sort of delicate, harp-like organ, of which these fibres represent the cords. Upon this resemblance Helmholtz founded his theory. The vibrations of the external air are finally carried through the basilar

membrane to the organ of Corti, and each note causes a fibre to vibrate. These vibrations are carried to the brain and, in this manner, we have the sense of sound or tone and by their combination, that of music.

This theory has a dangerous facility. At first sight it seems plausible, and accordingly it was taken up enthusiastically in this country, and Tyndall gave it vogue with all that eloquence which secured for him the title of "the poet of science."

The theory, when looked into, becomes less acceptable. In the first place, there appears to be confusion, which is always cropping up, that a sensation corresponds to the form of the stimulus, as if, for example, we saw a tree by virtue of the image of the tree being carried along our nerves and deposited on the brain. Sensation is one thing, the external stimulus quite another, and if it be asked what corresponds to the actual reality, the answer is that the question has no real meaning. We have the concurrence of two things, each very complex—the external stimuli and the system of our nervous structure. Here already in conjunction with these two domains we have something produced which cannot be summed up in the terms of either one or the other separately; and then when the sensation arises we have something not merely entirely new, but something in another sphere altogether. So much so that all we can

assert by way of connection between the two is, that the physical events are correlated to the mental. We cannot even determine clearly what is meant here by the word "correlation," but we seem to be justified in saying that when a certain physical disposition of the nervous system exists, there will exist certain psychic states, such, for instance, as those of sensation.

The theory of Helmholtz, therefore, seems to have arisen from a conception which was too crude to satisfy the conditions required.

On the other hand, although the fibres of the basilar membrane change in length as the membrane on which they were laid forms its spiral in the cochlæa, yet the lengths do not correspond to those of the strings of a harp producing corresponding notes.

There are also other objections in the sense that the fibres, though numerous,—Kölliker says 3,000 cords—do not correspond to the number of separate notes which we can perceive.

Other theories have been formulated. Ewald, of Strasburg, in the year 1899, made a model of the basilar membrane and, by means of a microscope, studied the movements of the membrane, in response to notes of various pitch. He concluded that even on this ground the theory of Helmholtz was not valid, for the whole membrane responded to the various notes in turn, each note, however, corresponding to its own peculiar disposition of vibration.

These experiments of Ewald, though conclusive so far, did not touch the other question of the meaning of sensation itself. A new theory, therefore, was put forth by Rinne, and afterwards promulgated in this country by Professor Rutherford in the year 1886. Very briefly expressed, Rinne said that the basilar membrane responded to all the notes in a manner somewhat similar to that of the drum of the ear. (It was this part of the theory which was afterwards confirmed by Ewald.) The vibrations were transmitted to the terminations of the auditory nerve, and are sent up to the brain to be analysed there.

Much more recently in Paris M. Marage has developed this theory of Rinne, and expounded it in reference to a series of experiments and observations, and he has concluded that there is a system of centres in the brain, each one corresponding to a certain stage of association of the sensations corresponding to the external stimulus.

Finally we have the matter settled in a style that points another moral. Sir Arthur Keith, in the course of a lecture at the Royal Institution, on "The Theory of Sound According to Sir Thomas Wrightson," put forth an explanation which is really that of Marage. This, however, happened during the War and, in a notice which I find of the lecture, the heading runs : "A Crude German Theory Confuted," and Sir Arthur Keith himself

is represented as describing the suggestion of Helmholtz as "the crudest and most impossible theory ever forced on the world."

"It is habitual," he said, "for us in England to overlook the discoveries of our men while they are living, but as soon as they have gone, we suddenly discover them."

With that last remark I entirely agree, but whereas, in Tyndall's day, Germany, German science, German poetry, German culture, German morality, were all held in peculiarly high esteem, and Tyndall enhanced his own reputation by supporting the faulty theory of Helmholtz who was, moreover, one of the great men of science of all time; yet now it is sufficient to rehearse the errors of a German and pander to that petty and brutal spirit of prejudice by which enmities between nations are kept alive. This is as unscientific as it is immoral.

In the theory of vision Helmholtz also occupies a prominent place, for he has put forward the suggestion that, since all the colours of the rainbow can be produced by combination of three of them —red, green, violet—the end organ of vision consists of an arrangement of elemental organs, each reacting to the appropriate stimulus of the undulations of ether corresponding to red, green and violet. The theory was originally due to Thomas Young, one of the pioneers of the undulatory theory of light, who put forward the

suggestion that the pictures of the old masters might be classified according to the relative proportions which they favoured of the fundamental colours.

It will be seen at once that Young and Helmholtz have given us, not a theory of vision, but rather that of the composition of colour. The theory, however, although it has little to support it in the microscopical structure of the retina, is still almost universally taught. It has the merit that, when once accepted, it negatives the desire to ask further questions.

Several other theories have been in turn propounded by von Kries, Hering and Edridge Green. Edridge Green was led to the study of colour vision through his first work on the Memory, in which he sought to localize some form of the memory in the optic thalamus. These investigations led him to ask questions as to the manner in which combinations in elementary sensations took place, and from that he was led again to close examination of the various organs of vision and, finally, to a series of brilliant experiments on colour vision.

Edridge Green's results ran counter to the accepted theories of the day, but as he was the only man who had appealed to Nature herself to decide, it might have been expected that the current theories would give way and that his conclusions

would be recognized. But it must be remembered that when a theory has been accepted and has received the stamp of official recognition, it stands no longer as a mere theory but it becomes attended by a host of satellite functions; textbooks, official rules, routine procedures, lectures at the Medical Schools and Universities and, finally, the reputations of the professors.

It was into this hornets' nest that Edridge Green dared to intrude with a plea so petty as that he had discovered the truth of the matter, and armed with the sole and ineffective weapon of reason. His misfortunes then began, for it is on record, I believe, that the opposition to his theories was pushed so far that the Royal Society, in the defence of one of its eminent members, intervened to prevent Edridge Green obtaining an honourable situation to which his talents and his discoveries had entitled him.

In this case, however, scientific ability was allied with great perseverance and sufficient audacity to enable a man of genius to hold his own against the onslaughts of a hierarchy of powers. I speak with a certain degree of knowledge because, during my term in Parliament, I was of some small assistance to him in his struggle against unequal odds and unfair methods. I was able to observe, not without some consternation from behind the scenes, the kind of engines which learned societies and govern-

ment departments are capable of putting to work in the course of denying justice to a thinker who propounds unpopular or inconvenient views.

It is usually conceded by scientific men that important mistakes have been made in the past, but they always conclude with an air of self-satisfaction by declaring that any injustice of the sort is impossible nowadays. Is this really so?

I would say, so far from that being the case, I think there never has been a time in the history of science when that evil influence has been more predominant. That is one of the reasons why I have dwelt for a moment upon the case of Edridge Green. For twenty years he fought a desperate battle and, during this time, he was continually misrepresented and his work was disparaged. He has at length won recognition, not only in this country but throughout the intellectual world. It was the appreciation of his work amongst enlightened men in other countries that compelled the authorities here to see that a wrong had been committed. The proof of the matter is that he is now honoured and his theories accepted in quarters which gave equally convincing reasons, or which appeared to be convincing, for rejecting him.

The difficulty about bringing home affirmations of this kind is that, in the nature of things, it is not easy to furnish a proof, at least within the lifetime of the victim.

When the Council of the Cardinals, for instance, condemned Galileo they did not make a statement to the world : "Here is a man of genius who has made great discoveries and sent forth thoughts which will at length mould the whole course of civilization ; but because he holds opinions which run counter to our doctrines, of which he shows the baselessness, then, since if these doctrines go by the board our whole system and we ourselves will suffer in credit, we use our powers to condemn and silence him."

What they did say in effect was : Here are we, the Great Authorities in these matters of learning and understanding ; we hold the highest positions in the realm of thought ; we are dressed in gorgeous raiment ; our authority is acknowledged far and wide ; and here is an abominable upstart whose works have never received our imprimatur and who, from the depths of his ignorance, or from the height of his impudence, utters sayings that strike at the very fabric of our age-long teaching ; and who, moreover, is a wicked man, a scorner of the sacred rules of our discipline, a mocker of our order —at this point the mob rises, they have heard enough, they pursue the wretched Galileo with yells of execration, fierce cries for his immediate extinction.

I take leave of Edridge Green for the moment, and I do not know that it is necessary to pursue

through all the categories the false teaching which has become consecrated in our Universities and Medical Schools, for one could cite a case at every turn.

At this challenge, let us take one at hazard—the Voice:

In the larynx are found certain organs called the vocal cords which are concerned with the production of the voice. Now sound is produced as the result of the vibration of cords and perhaps on account of this somewhat unfortunate name, the theory has been put forward as sufficient that the sounds of the human voice are produced by the vibration of the vocal cords; it is even pointed out that the difference in pitch of the voices of man and woman are due to the difference of length of these cords.

If one, however, casts a cursory glance on a piano or a harp and observes the length of the strings required to produce notes of the pitch currently used in ordinary speaking or singing, and compares these with the short lengths possible in the human larynx, it becomes evident that the theory as usually put forward is far too simple to be true. Certain observers taking note of this fact have compared the larynx rather to an organ pipe; but here also the comparison has been based upon too superficial a resemblance.

This is not the place to discuss in full the theory of voice production, but it is evident that we must

take into account not merely the vocal cords and the tube of the windpipe, but the complete structure of the larynx, the pharynx, the nasal passages, the mouth—all of which form the essential parts of the instrument in which the vibrations, which finally give rise to the notes, have been produced by an extraordinarily complicated series of actions and reactions. But our students will for many a day use the term "vocal cords" as an open sesame to the house of Authority.

One other case may be noticed, if only for the laudable desire which has been shown by Professor A. V. Hill to introduce into the study of physiological processes the exact determinations required by mathematics. At the meeting of the British Association at Southampton in 1925, Professor Hill read a paper which was the most widely reproduced of all of those submitted on that occasion.

His thesis may be thus briefly expressed: The maximum speed at which a given distance can be covered, say by an athlete, is determined by fatigue. Of fatigue there are more types than one but not all of these are susceptible of accurate measurement. Let us cast our attention therefore upon that which results from extremely violent effort carried on, as it must be, for a short time. Any effort of the kind results in the expenditure of oxygen. The man becomes exhausted when he has used up his supply of oxygen. The maximum

intake of oxygen per minute averages four litres and, allowing that reserves may be drawn on to an equivalent of fifteen litres, it follows that oxygen may be used up at the rate of nineteen litres for one minute. For two minutes we would require twice four litres current, added to the fifteen litres credit ; that is to say, twenty-three litres altogether, or eleven and a half litres per minute. For any greater length of time the amount of oxygen can be calculated on the same principle.

Proceeding in this way, Professor Hill reaches certain conclusions which are more or less in accordance with known facts, but it does not follow for a moment that the theory he puts forward constitutes a sufficient explanation of the observed phenomena. Professor Hill deals only with the question of fuel ; but even in a machine the question of fuel is not the decisive factor. On the same amount of petrol, for instance, one car may run twice as far as another. In the human organism, however, we have a much more complex machine, and one that is not at all efficient for more locomotion, because it has been built to subserve a thousand other uses besides that of rapid movement. Of two athletes possessing somewhat similar build, one may be far more efficient than the other, and the calculation of fatigue on the basis of using up oxygen may be extremely wide of the mark.

The human body contains not only a muscular

system, but a nervous system, an osseous system, a circulatory system, a digestive system, a lymphatic system, and each one of these is itself extraordinarily complex ; and between two athletes in whom there is a fair resemblance on general lines in this regard there may be enormous differences due to the modes of co-ordination of the parts, as determined first anatomically and then by the training which guides a due release of energy at the proper moment.

Leaving aside, however, these little incidentals, let us examine one or two of the arguments of Professor Hill, which leads to concrete results. He draws a comparison between the masculine and feminine form, and he finds that the speed of the man is superior to that of the woman, say in a hundred yards' race ; then he brings in one of those mathematical touches which are so convincing, and he says truly that the height to which a body can be thrown in the air varies, not as the initial speed, but as the square of the speed, and so he proves definitely that a woman can never jump as high as a man. Incidentally, I have known arguments not less convincing which have proved that no woman could ever swim the Channel.

But to return to this question of speed and height. Now, since mathematics knows nothing of sex, the argument would be true as between a fast sprinter and a slower competitor. We prove by our mathematics that the slow man could never hope

to compete with a fast man in the high jump. When we compare these theoretical results with facts, we do not find them verified. The men who have successively held the record in the high jump have never been champion sprinters nor, on the other hand, have the record sprinters ever been champions at the high jump.

The action of the most highly trained jumpers does not give a suggestion of speed such as a sprinter employs. The machinery set in motion by the jumper differs very widely from that of the sprinter, as does also the regulation of those impulses and sudden release of great energy, which are difficult to define anatomically or to express mathematically.

The long jumper does depend far more than the high jumper on a preliminary burst of speed, and I remember that an athlete who held the world's long jump record for many years, P. O'Connor, told me that he used to call upon an effort of fiery dash the moment before taking off. But even here the argument of Professor Hill fails, inasmuch as it is derived from a comparison of sprinting times for, again, hardly any of the famous long jumpers have distinguished themselves as champions on the running track.

What Professor Hill has done has been to simplify the conditions of the case to suit his mathematics. This method, we have noted, has been employed again and again by the expert mathematicians when

dealing with physical problems ; by Euler, by Lagrange, by Helmholtz.

The physical problem dealt with by Professor Hill is enormously more complex than that which has been tackled by the mathematicians mentioned, but, on the other hand, Professor Hill's control of this instrument is much less effective.

The point I make is that he was credited not only with having given an interesting discourse, but with having produced an exposition of the problem of the athletes' movements reduced finally to expression in exact mathematical terms.

What he has really done is to offer us a charming, if not quite accurate, talk on athletic feats, with the reassertion of what has long been known by Macaulay's learned schoolboy, that $v^2 = 2\,gh$.

Some of the modes of acquiring popularity on this very subject of physiology are still more subject to criticism than those of the vague wanderings of Professor Hill in the realm of applied mathematics, for A. V. Hill is one of the best types of the modern professor ; a man not only of high competence in his own sphere, but well developed all round and alert to intimations of intelligence from widely separated sources. All that tends to the acquisition of grace on his part, but it does not make a bad argument good.

Running my eye over the achievement of others in the same realm, I found that one of them, whom

I will not trouble to name, began an address at the British Association with allusions to Charles I, Charles II, George III, and the Prince Consort. I was puzzled to know the connection between these citations and physiology, until I observed the titles and decorations with which the professor was plastered. This shows the kind of influences that can be brought to bear on discussions in science, but the British Association seems to revel in that sort of misfeasance.

Before quitting this realm, however, I wish to sound another note. Claude Bernard is one of the great founders of the science in its modern guise, and to him physiology owes the great impetus of which it is still enjoying the benefit in these days. It may be mentioned incidentally that his work, indirectly through Lucas on Heredity, inspired Zola and suggested to him the plan of writing the Rougon-Macquart series in the form of an exposition of a genealogical tree, dwelling principally—for the mind of Zola tended in that direction—on the aspects of decadence. The laws of heredity, however, are complex, and not sufficiently known to allow of satisfactory exposition on these lines, and Zola's work has been hampered by his endeavour to keep it within a certain preconceived groove which, however, exercised no restraint when his instinct as a romancer and his lyric inspiration make light even of the trammels of his realism.

Wurtz, the chemist, who was a contemporary of Claude Bernard, desiring on one occasion to show to his class what chyle looked like, and not having any at the moment, prepared a mixture with chalk and other ingredients and handed round the bottle containing it. I have the story from M. Dastre, who combined great specialized knowledge with a philosophic outlook. He told me that when Claude Bernard heard of this trick he was quite disturbed by it. He said: "I could not have done anything like that. If I had, I would have had the vision before me of fifty students each rising in his place and pointing at me with accusing finger, crying: 'You lie'—'you lie!'"

In the service to truth, and not in paltry social honours, lies, or rather should lie, the reward of science.

CHAPTER NINE

PSYCHOLOGY

SO far, we have been marching, sometimes adventurously, but always in contact, close or remote, with reality. We come now to an alluring world where reality may be a far-off objective, but where none of the paths opened up have shown any likelihood of attaining it.

The very name of Psychology and Philosophy—for it is of those subjects that I now speak—have been belittled and rendered almost ridiculous by great professors of these sciences.

The chemist, even though at times he has to seek the deeper explanation of things in a field at first extremely obscure, reaches definite results and magnificent concrete achievements. The triumphs of the physicist are still higher, for his combination of enlightened imaginings, aided by his mathematical apparatus, tested by accurate estimation, have given to the human race marvels far greater than those of the Seven wonders of the world of old. The mathematician, though he seems often remote from the living world, is yet developing an instrument which always refers to definite reasonings, and which has given to man, as Darwin said, some-

thing like another sense. When students of these subjects therefore turn their attention to subjects such as psychology or philosophy at large, they are apt to be disappointed both by the elusive nature of the expositions and the sheer futility of the result. They turn away and deride psychology.

To that extent I sympathize with them ; but their view is also partial for, as the Greeks of old felt, these subjects of philosophy should be the peak of all the scientific endeavour. It is there that we find the application of what otherwise are a series of interesting facts ; they are brought to bear upon the inner meaning of our own lives and our destinies, and in these visions we see more clearly the lines of true guidance in the difficulties amid which we wage our human existence.

To illustrate these matters I take one or two of the famous philosophers whose influence has been most potent at our Universities, thence spreading downward till it has interpenetrated our modes of thought and given us a sort of atmosphere in which we view the delicate things of the mind.

The great figure in modern philosophy is Kant ; but I do not propose at present to investigate all the intricacies of his *Critique of Pure Reason*. I think it was Lichtenberg who said that those who thrashed out their way through Kant's philosophy were so fatigued by the process that they were reduced to believe in anything. If this be

so, it is not that they have been dazzled by excess of light, but exhausted by the vain attempts to find something on which the mind could seize in that shadowy world where Kant himself lost his intelligence.

It is necessary, in order to understand Kant's philosophy, to know something of Kant. The reader may exclaim out on this, as if it were introducing a lower standard of criticism, and that objection would be true if Kant dealt entirely with objective matters; but in the first place, even in mathematics, which is far removed from human passion, one has a clearer understanding of the work of a thinker if something is known of his style and temperament, and particularly of the source of his ideas. Klein has emphasized this point in an admirable address on Riemann's work.

Kant was of a Scottish family, who spelt their name "Cant," but who left Scotland and settled in Königsberg, where his father pursued the trade of saddlery. Scotland at that time was the land of theological disputes, and Kant was brought up in that atmosphere. He was the typical intellectual child, almost too spectrally bright in intelligence, and endowed with a mind whose precocity tended to impair the full and harmonious development of his nature. In his later days, Kant was a sort of local institution in Königsberg; always at the same hour in the afternoon the little dried up atomy

of a man, in his grey coat, with his Spanish cane, could be seen setting out for his routine walk under the trees—the Philosopher's Walk, as it is still called in Königsberg—and in the course of which if a drop of perspiration showed itself, Kant was struck with consternation. His great excitement during the day was the arrival of his cup of hot coffee, for which he waited with an eagerness never impaired by custom but always mounting at the same hour to the precise degree of excitement. Though small, and delicate in constitution, he had also received as a legacy from his Scottish ancestors something of a stoic bearing, and an admiration of endurance; but withal he was the very type of what in the old books of medicine used to be called "the nervous temperament."

Kant read largely and widely, but his intellectual acquisitions have been exaggerated. Philosophers admired his mathematical skill, without knowing anything about it; and the mathematicians and physicists, finding his nebular hypothesis rather too nebulous and his mathematics not highly developed, expended themselves in wonder at his philosophy, which they did not understand.

In accordance with his temperament and his descent, Kant's main interests were really ethical, but no man has ever written on this subject whose experiences were so limited. He never left Königsberg, and his life in that quiet old town was in

its circumscribed range as devoid as possible of change.

Yes, it may be said, but the intellectual power was there ! He did not need experience—he evolved everything from his own reasoning.

In the first place that would be difficult enough in the most abstract of the sciences where, although the appeal is to experiences which are rudimentary and common, yet there is that appeal and to a much greater extent than is generally believed ; and even there mathematicians have been continually at fault and, in the region of applications, frequently led to erroneous results.

But ethics is something different to all this ; it is as complex in the realm of philosophy as the science of meteorology in the realm of applied physics ; and one might as well try to work out a theory of the weather from one's inner consciousness as to speak intelligently of ethics from the same source. A true comprehension of ethics involves a sympathetic understanding of the great motives and passions that impel men throughout the whole scope of life ; these, moreover, must be estimated in their value and quality taken in conjunction with the complex motives of interests, and all interpreted in the light of a true intellectual outlook upon the conditions of the actual world in which our lives are wrought. To ignore all these matters is to talk moonshine, and that is really the feat that Kant achieved.

In default of necessary experiences, Kant relied upon his intellectual acquisitions ; his training was in great measure classical and his mind was filled with those records of old happenings which come to us in history in a somewhat veiled and mystic manner, false in perspective and void of the impact of reality except to those whose experiences enable them to interpret the teachings.

Then again, there were the suggestions of his own temperament and the mystical atmosphere of religion, generally represented in the form of religious strife which was like the breath of his nostril. Out of all these elements Kant fabricated a system of ethics which reflected both his strength and his weakness. The stoic force of his character is there and, corresponding to the expression of his nervous temperament, falsely pressed to an impossible degree ; so that Goethe, though not a trained philosopher, had wit enough to see through the absurdity of Kant's teachings. But the stoic within him was overcome again by the sickly and craintive imaginations of the little secluded valetudinarian who was terrified by the first rumblings of that mighty social upheaval which we know as the French Revolution.

Against this storm he took refuge in an artificial and completely unwarranted little system of philosophy which, expressed in less pompous or impressive language, was simply that of what was after-

wards called in Germany the "reptile press" in its glorification of the Hohenzollern system. This has some significance for us to-day because the same sort of philosophy was afterwards expressed with greater dogmatism, obscurity and abject sycophancy to the Hohenzollern monarchy, by Hegel and other followers, more or less direct or indirect, of Kant.

Hegel is indeed so obscure that, as he himself said in a rare flash of illumination : "Only one of my pupils ever understood me and,"—he added on reflection—"he misunderstood me !"

It is this misunderstanding which has given force to Hegel's teaching for, on the one hand, he is claimed as a philosophic buckler by the Hohenzollerns and, on the other, as an intellectual banner, by Karl Marx. Of course the practical philosophy in neither one nor the other depends on any sense of an organic development of the elucubrations of Hegel.

To return to Kant, however : He saw one thing clearly for which he deserves our entire respect. Proceeding from the basis of ethics and making use of an intellectual instrument in order to define that realm, we are forced to look into the manner of working of that instrument itself, its power, its scope, and also its limitations. That leads us to a study to which the term psychology should be especially reserved.

Kant having seen the necessity of founding on the deepest basis of psychology, sought by means of analysis to discover the fundamental elements of thought. In this, however, he was unsuccessful and the subsequent development of his philosophic and ethical systems really does not depend at all on his establishment of the "categories."

Long before Kant, as we have seen, Aristotle elaborated a system of ethics and, in the search for a basis of this system, he too was inevitably led to seek for the elemental forms of thought—what I have since defined and henceforth will call the Fundamental Processes of the Mind—in order on this foundation to build up regularly in close sequence and by good arguments the exposition, which would finally result in practical directives.

Every science which has grown and developed and stood the test of comparison with reality, has necessarily proceeded in this manner; tentatively, perhaps at first, but after certain developments, with a recognition of the necessity of such a foundation and a deliberate search for those elemental forms which are sufficient and necessary to cover the whole field.

Aristotle failed, as we have seen, and Kant also; but Aristotle's system of ethics, though lacking a strict scientific expression—replacing this indeed by the wealth of experience and the artistry of a highly accomplished mind—this system of Aristotle

appears to me to be one of the most marvellous fabrics ever produced in human history. One observes therein not only the keen intelligence of the Greek, but his easy, plastic, sympathetic nature, and withal through it, interpenetrating every fibre, that glow of the "Mediterranean smile" which is absent in our later ethical legislators.

Hutcheson, Adam Smith, John Mill, Herbert Spencer, Ruskin, Carlyle, were all sexual invalids. There is something in their writings which suggest to me a kind of polarized vision, and their high reaches of ethics have an air of narrow intensity, of hysteria, of a chlorotic and false sense of morality. The word so often used to describe these high peaks of human endeavour—'spirituality'—has at length impressed itself on the world by a tone of spurious and immoral suggestion. It is frequently used in this way: Such-and-such a thesis may not be true, but in a certain high and spiritual sense, don't you know, it is greater than reality.

This is a puerile manner of speaking and as wicked as it is false. If the stars in their courses fought against Sisera and vanquished him, we may be content to suppose that the forces of nature will toss aside as withered reeds these false shoots of undeveloped minds.

Here I want to say definitely and prosaically, for there is always a liability to be misunderstood and misrepresented, I do not want to preach what is

called a low materialism ; on the contrary, I think that the beacon lights of idealism should be for ever before our eyes, guiding us, not merely in ecstatic moments, but in the ordinary course of our everyday world, which then itself becomes wonderful and inspiring ; but I ask that the ideal should be in accord with truth and linked indissolubly to the real ; without antithesis but simply in the natural form of development. The sole atheism is the denial of truth. That is found most commonly amongst the great religious teachers.

Kant was one of these both by his nature and profession. He did not write his *Critique of Pure Reason* firstly even to establish the basis of a system of ethics, but with the main objective of overthrowing Hume. He did not overthrow Hume, but, if he had done so, he would have done nothing of that permanency and inevitability implied in the foundation of a true system.

Hume was a keen critic, and his destructive powers were enhanced by the brilliancy of that academic style which had great vogue in his time, and which, in another form, has served to give lightness and piquancy to the massive form of Gibbon's work. But there is no deep base in his system of thought, no sense of organic development. Again and again one must insist on this, until it becomes as plain as that two and two make four. There is no other way of building a science,

so as to make it something living and developable and finally of importance in its application to our ordinary lives ; no other way except that of the manner in which the positive sciences have been established.

I do not mean to say that the process of thought by which a science is extended, or new discoveries made, must have a formal or even a disciplined aspect. On the contrary, I think that herein our books of logic are altogether misleading in the sense that they seem to indicate that the mind necessarily proceeds along syllogistic forms. Elsewhere I have indicated the lines of a new form of logic, to use that term for a moment, which would bear the same relation to the old formal and barren logic that the views of biology brought in by Darwin's ideas, bear to the artificial classifications such as Linnæus.[1]

But though the mind may expand in imagination, in tentative efforts of discovery, yet the results must be brought to the criticism of the standards which arise naturally from the deepest seated establishment of the science. It has been the failure to recognize this which gave us first the "thousand years of night" preceding Galileo, and right up to our present day produces the vapid streams in the realm of thought which pour regularly from the University Press, or the hotch-potch of chaotic

[1] Cf. *Psychology : A New System.*

and incongruous sayings lit up now and then by fuliginous beams, such as Carlyle was able to throw upon the Kant-born, Fichte-cultivated raving of his "Entsagen," and the rest of the Teutonic nonsense in which his sentimental soul lost its reason, and gained the glory of homage to a sage.[1]

At this point I introduce another name for which I have great respect, that of Herbert Spencer. There was a time in an early course of my studies in philosophy when I was so much impressed by Herbert Spencer's work that I thought it a task sufficient to recompense a lifetime to spread this teaching and to exhibit it in the diverse ways of its thousand corollaries.

After closer examination, however, I have been forced to the conclusion that Spencer's whole system is devoid of scientific sanction. Even the factors which produced its vogue appear to me now in quite another light. Lafcadio Hearn, for instance, spoke of Spencer with bated breath ; but

[1] I have been criticizing Carlyle from the scientific standpoint and there I hold that no force of attack can be too strong for, if the argument in question be a true one, then the more severe the criticism, the stronger, if it be strong enough to resist, will be the position maintained. There is no book, however, which I have read and re-read more frequently than "Sartor Resartus," and not only with undiminished enjoyment of its wit and humour and picturesqueness of idyllic scenes, but also with fervent appreciation of the flashes of vision and the urge to high ideals.

this impression arose in part from the sheer bulk of the philosopher's production. A man who produces a dozen stout volumes finely bound, exhibiting as their coat of arms the development of a butterfly from a chrysalis, must necessarily speak with great weight. Those volumes, however, with their successive titles : *Biology*, *Psychology*, *Sociology*, etc., are really the applications of a principle which, itself, might have been expressed within a small compass. Biology, for example, does not underlie Spencer's system in the sense that out of these studies of Biology has arisen a conception of the system which he has enunciated as his great principle. It is really a principle of evolution plus a biology. And so with the Physiology ; it resembles that of Wundt in being not a physiological psychology but a physiology and a psychology. Herbert Spencer has in fact built up his massive tomes by taking textbooks wholesale and paraphrasing them, and using them at every turn as illustrations of the application of his evolutionary principle. Looking at these works recently again I was astonished to find how faulty was his science. It was as "dated" as a mid-Victorian bonnet.

Another suggestion arises here, and that is, that if the basis were so precarious it could not possibly serve to build up a science of a permanent character ; and if the building up of the science were independent of this basis, then the great part

of the work must have been what is called padding. This procedure implies no lack of wisdom, for, flung at the head of Lafcadio Hearn, the series of the books produced the required impression, and Lafcadio Hearn was an exceptionally intelligent man. If, however, we perform a sort of philosophic dissection and remove all that is either adventitious or accessory or better expressed elsewhere, we find on the one hand the principle so often referred to, of evolution ; then, on the other, various opinions, criticisms, and suggestions of Herbert Spencer, an excellent and honest bourgeois, but not necessarily endowed with any special sanctity. If Herbert Spencer, instead of promulgating his doctrines in his heavy, lumbering style, had something of the wit of Voltaire, who was really quite as serious in his thought, and if he had exercised an added skill in order to reduce the volume of his works to the twelfth-part of their proportions, he would have produced a much better book than any that now stands to his credit, and he would have missed nothing essential; but with this added grace, he would have lost all reputation, he would doubtless have been dismissed by the authorities as a light-weight amateur.

Let us, however, look to the famous principle itself, but since it is too much to expect that one should wander through all these tomes and boil them down successively, I propose to give, without delay, the indication of that which should be sought

for in all works worthy of study at all—the germinal idea.

Herbert Spencer was an evolutionist by a sort of intuition, long before he had convinced even himself by the elaborate arguments of his massy volumes. Having accepted the main suggestion, he set himself the task of expressing this in an all-comprehensive formula. He was never quite satisfied with the result, for he has given several versions, though these are in accord in the main lines. In order to trace out the course of development Herbert Spencer referred to the organisms at the opposite ends of a long course of evolution—the amœba at the one end and man at the other. He assumed the amœba to be an almost homogeneous being, and he noted an extraordinary complexity of the organization of man; and, from considerations of this kind, step by step, he tabulated the differences; and then he sought to retain only those that were essential and not capable of being derived by composition of others; and then, finally, he expressed the whole matter in terms of great generality:

"Evolution is an integration of matter and concomitant dissipation of motion; during which the matter passes from an indefinite, incoherent homogeneity to a definite, coherent heterogeneity; and during which the retained motion undergoes a parallel transformation."

Spencer found this enunciation incomplete and added to it the condition that a higher evolution was

characterized by greater definiteness in Time and Space.

Even then, however, he certainly does not give us the principle of nature in the sense in which an architect's plan really constitutes the vital directive by which a building may be constructed. On the lines on which he was working Spencer has not covered the entire scope of the indications supplied by the study of the amœba and man.

Herbert Spencer's notion of the amœba as a homogeneous being does not correspond with the facts. Any living organism must be capable of growth and repair and, since the raw material comes from the environment, it must be furnished with means of choice—reactions, conscious or unconscious ; there must be some mode of conduction of impulses which, in turn, produce change in disposition of the organism. So far we have dealt only with the receipt of the external product, that is to say, the food. Then there must be some process of digestion, of assimilation of products of digestion, and of excretion of the waste material ; also the special dispositions which subserve the purpose of reproduction.

I need not pursue this argument, enough has doubtless been said to show that if a brick, for instance, were regarded as a homogeneous element, the amœba would be as complex in structure as a Town Hall.

Further, apart from the vagueness of his terms, he omits essential standards.

A theory of evolution should take note of the control over nature by the expenditure of the minimum of energy. Life, whether of the amœba or of man, consists in a sort of contest with natural forces which either tend to the detriment of the individual or which, if properly seized upon, can be made to subserve his advantage.

In the second place, since a body grows by accretion of mass, mass itself becomes one of the criteria of higher evolution, other things being equal.

Thirdly, since the mere addition of mass would not carry the individual far, there should be some definite standard of ascertaining the most efficient means of co-ordination of all the parts as the body grows in complexity.

Fourthly, there should be a means of noting the potentialities of further development, with a guide that serves to distinguish progressive or retrogressive development.

Fifthly, in finding such a guide, or standard, we must take note of mental operations, and purposive actions.

Sixthly, the efficiency of the individual, judged by these criteria, should have some relation to what, using a term for brevity but interpreting it on a wide basis, we may call the Moral principle.

Consideration of all these matters should be

carried out with determined search and meticulous care; and then if all the standards were seen in proper co-ordination, one would arise from this view with a clearer apprehension than Spencer's of what should be implied in the term progressive evolution. I have dealt with this matter elsewhere[1] and there is no necessity for me now to enter further into the question.

When I was a student in Berlin I found that more importance was attached to the works of Alexander Bain than to those of Herbert Spencer. One reason for this might be found in the fact that Bain's style was more professorial and that his writings, being more technical and more in accordance with the orthodox works on psychology, lent themselves better to an exposition in the University course.

On the other hand, Spencer had not sufficiently developed his principle in such a manner as to show how a superstructure might be built upon it. His numerous weighty tomes do not, as I have already suggested, constitute such a superstructure. They are really of the nature of illustrative comment. His handling of the various sciences which he introduces rarely show sufficient mastery of the principles of those sciences. M. Brunhès, in his interesting book, *The Degradation of Energy*, takes Spencer to task over a misconception as to the

[1] In the book, *Ethics*.

nature of stable, and unstable, equilibrium. This might be regarded as a detail, but unfortunately Spencer did not so treat it, for he has attempted to build upon it an argument tending to confirm his theory ; but this again shows how illusory his method is. He tried to attain so broad a basis for his generalization as to include inanimate as well as animate matter, but it would be possible to show in many other cases that his conception of mechanics was not sufficiently clear.

The problem of dealing with inanimate matter in such a manner as to show no breach of continuity up to the structure of living organisms is one that we will touch on later, in referring to Vitalism ; but even those who, like Kirchoff, cry : "There is only one Science—Mechanics !" may nevertheless recognize that the whole of the conditions leading to progressive development could not possibly be contained in Spencer's formula.

In order to afford some point of reference in the criticisms which follow of Freud and others of our contemporary philosophers, it is necessary to indicate in what manner true standards may be obtained.

Aristotle, we have seen, perceived clearly that he must pierce to the bottom of the meaning of our certitudes, or ascertain to what degree they might be looked upon as certitudes ; in other words, he

endeavoured to establish a basis of psychology. His investigation in this matter was all too hasty, and Kant in his turn spent but a few weeks of unsuccessful search, and then contented himself with an imitation of Aristotle.

Freud seems to have touched ground here for a moment ; then, without further prospecting, he went off at a tangent, following a remark of Charcot, who said to him, indicating his little troupe of hypnotized patients : "Sex is at the bottom of all this."

I can find no other philosophers who have been led seriously to search where Aristotle had begun to dig, but early in my own studies I became convinced that here it was necessary to tarry, and to pierce, and to excavate, as in opening up a hidden palace, till the foundations were made clear ; and it so came about that I spent twenty years in active thought, wrestling in the subtlest toils which had ever been presented to my mind, seeking for what I called the Fundamental Processes, by whose combinations all forms of thought could be built up ; baffled a hundred times, but continually led on again by the surety that there, and there alone, in the complete laying bare of the mechanism of these processes, lay the secret of psychology, the germinal idea which presided at the construction of mind. All these matters I have expounded in my *Principles of Psychology*. I will not elaborate upon

them now, further than is necessary to indicate the standards on which I offer my judgment.

Divers philosophies have been built up on the basis of each of these Fundamental Processes separately :

Freud has built his on Association.

Locke himself has played principally on Sensation, without seeking further to discover the mechanism of thought.

Schopenhauer has regarded the world as Will and Representation.

Bergson has made great play with his Élan Vital.

Once in possession of the whole instrument, one is able to see more clearly than these philosophers themselves what they were really driving at, and how and from what causes they missed seeing the whole ; and also, incidentally, how absurd is the structure of systems of thought erected on the basis of faulty imaginations.

If, for instance, a man be required to give an exposition of the working of the steam-engine, and if he has got no further than to observe the movement of the rod attached to the slide-valve, he will render a very faulty account of the steam-engine, and, as should be noted particularly, he will have a wrong notion even of the meaning of the rod.

Association is one of the series of the Fundamental Processes, which taken altogether constitute a working mechanism ; Memory is another ;

Immediate Presentation (which involves Locke's "Sensation") is another; the Sense of Effort (which holds the germ of what Schopenhauer calls "Will") is another; Impulse (by which whatever is valid in Bergson's conception of "Élan Vital" is explained) is another. But to separate any one of these and write a volume thereon gives me an impression similar to that of a description of a sunset by a colour-blind man.

What I have said already about Freud, when carried through to its proper application, is, I submit, a sufficient destructive criticism of Freudism as a scientific theory. It is not necessary to pursue, point by point, the arguments of a faulty exposition of science. Had Galileo attempted to refute, step by step, all the fallacies of the Schoolmen, he would have lost himself completely in the interminable wrangles which would have been produced. Instead of that, he selected for examination certain of their conclusions and, on appeal to something more deeply based than their reasoning, he showed that these conclusions were wrong.

Lavoisier, similarly, did not enter the lists in opposition to the tenets of the phlogiston theory by following close upon all the fallacies this theory introduced; he took a certain conclusion of that theory, and he showed that, on appeal to nature, that conclusion was not justified.

I say, then, that if, by an appeal to a deeper basis

of things and by arguments more rigorous and consecutive than hitherto known, the mechanism of the Fundamental Processes can be exhibited, then anything advanced in contradiction of this, especially in the tentative manner which I have indicated, must go by the board. That is definite.

It is interesting, nevertheless, to follow the vagaries of a popular craze, and find the reason of its success.

In previous criticisms of Freud I have been met by the retort : "I suppose you do not deny there is such a thing as Sex in the world?" I say : No ; I do not deny anything so obvious ; I do not dispute its overweening importance. I go much further than most people in demanding unfettered discretion on this subject.

It may be said : "Yes, for scientific works or for ethical purposes," but I do not feel compelled to stop there.

I think that the novelist, for instance, should be as completely untrammelled in this regard and free in the exercise of his art as the physiologist. But I enter an objection when I see false science, which could not stand on its own basis, made acceptable and rendered palatable by the artistic spicing and serving up of details which minister simply to prurient appetites. I have no more respect for Freud in this way than I would have for the author of a work on the Differential Calculus who fumbled

in his mathematics, and mixed up the exposition inextricably with the mysteries of a house of ill-fame.

It is from Freud himself that we gain the knowledge that he received his first inspiration from Charcot, the French neurologist who was especially noted in his day as the exponent of hypnotism. The fame he acquired by this meretricious side of his science obscured even the value of his solid work ; for Charcot was one of those men, not so uncommon as might be thought, who combine a great capacity of work and respect for scientific methods with a penchant to charlatanism.

At one time Charcot's lectures vied with first-nights at the theatre and attracted the fashionable ladies of Paris. They sat in the front rows fanning themselves, mingling the atmosphere of science with that of jasmine or violette de parme, chattering, laughing, joking and exchanging witticisms, but all attentive when the great man entered. Charcot, with his fine presence, his smooth-shaven face and regular features, with that air of gravity of his concealing the zest of the incorrigible joker, suggested at one moment Napoleon and at another Coquelin.

The performance corresponded to the theatrical presentation of the scene. Charcot's patients went through their acts in the flawless manner of a well-drilled company. They exhibited all the emotions in turn, from laughter to tears, from comedy to

high tragedy ; as when, for instance, one of the women rushed at a man to stab him with a glittering poignard, the poignard being a paper weapon. When a rude stranger once suggested that the act should be tried with a real poignard, the whole company was scandalized, and not least the homicidal lady.

If hypnotism had been of real value in therapeutics it should have been employed regularly through all the clinics the world over, but no one brought it to the same high degree of success as Charcot and his performing band.

He appears to have hypnotized Freud, for note that when Charcot gave his Austrian friend the idea of founding a new psychology, he did not impress upon him the necessity of searching to the foundation of things and building up in sequence. That procedure, although it has been found necessary in every science where the conclusions can be tested, was too banal for the genius of Freud. Charcot had given him a hint of far greater potency—to build on Sex—and Freud has certainly bettered the instruction.

I have, for my sins, read through nearly all Freud's writings until, for a time, I seemed to be as much haunted as himself by the eternal sense of Sex ; but through it all I was unable to find anything but the most fugitive glimpses of mere science. One of the most extraordinary of his books is that

which he devotes to Leonardo da Vinci, who was one of the bright stars of the Renaissance. Leonardo was accustomed to keep a diary, and he has left behind him notes the full significance of which we have only in recent years been able to appreciate, for he was much preoccupied with the problem of flying. In one of his notes he says :

> " It seems to me that it had been destined before that I should occupy myself so thoroughly with the vulture, for it comes to my mind as a very early memory, when I was still in the cradle, that a vulture came down to me and opened my mouth with his tail and struck me a few times with his tail against my lips."

This passage really makes the corner-stone of Freud's book for, apart from this and the interpretation he gives to it, he finds nothing new to record.

He remarks in the first place that ordinary readers may not attach great significance to this passage, but that nothing is too small to escape the notice of a psycho-analyst. He then makes the assertion that the story is a pure fantasy because no one could recollect an incident which occurred so early in life.

In the first place, if Freud had been more meticulous in his attention to detail, he would not have said that no one could recollect an incident which went back to the cradle. I could cite the testimony of people, not especially remarkable, to the contrary. Moreover, Freud in this case has nothing to build on except the testimony of Leonardo himself ; and Leonardo says decisively that this is a memory.

That detail was too small even for the psychoanalyst or possibly, since it was a matter of fact, it came within the category of things which he was entitled to ignore. For his interpretation of the incident is this : " My mother has pressed on my mouth innumerable passionate kisses,"—and this theme he elaborates and expands at great length, but I cannot bring myself here to quote from it.

Another note of Leonardo's diary records the death of his father :

> " On the 9th of July, 1504, Wednesday at seven o'clock, died Ser Piero da Vinci, notary at the Palace of the Podesta, my father, at seven o'clock. He was eighty years old, left two sons and two daughters."

Freud's comment upon this is :

> " Without Leonardo's affective inhibition the entry into the diary could perhaps have read as follows : ' To-day at seven o'clock died my father, Ser Piero da Vinci, my poor father ! '
>
> " But the displacement of the perseveration to the most indifferent determination of the obituary to dying hours robs the notice of all pathos, and makes us recognize that there was something here to conceal or to suppress."

What there was to conceal or suppress Freud, knowing nothing of the facts, is able to supply abundantly from his own prurient imagination.

Suppose this " Columbus of the Mind " had to deal with Little Jack Horner and his historic saying, one almost dreads to think what he would have made of it. Perhaps it would have run somewhat to this effect : Here the Inferiority Complex might

in dealing with this compulsive type, have resulted in a mental struggle (Conflict) leading to the inhibition of his pathography, unless the Repressive Complex (doubt conflict) drove him to the Abulias either by fixation or sublimation of the Sex Instinct or the certain esglow (Libido-quantum) of an erogenous zone of perverted imaginings (Freudism).

Having written this under a Freudian inspiration, I am not quite sure what it means, or even whether it is English, but I would ask the reader to compare it even on this score with the short passage about Leonardo which I have quoted.

Freud deals with questions of memory, and certainly there is room there for a Columbus, since for two thousand years every successive professor who has ever felt called upon to write a book on this subject has begun by running through a considerable quantity of the literature of his predecessors, and making compilations and paraphrases in order to serve these materials again to the public.

The proper method—and I say this with some sincerity, for although it is the most difficult, it is that which I chose myself—is to observe and experiment in order to get determinations as precise as possible. Some of my own experiments were laborious, for they extended over a number of years; but as they had been especially set up in order to arrive at clear determinations, I had in the end at any rate that advantage.

Freud has done nothing of this sort at all, and he talks such nonsense on the subject that it would be apparent even to all his readers did he not divert their attention by the resources of his inevitable details of pruriency.

In dreams, of course, he revels and, of course, he talks again abysmal stuff. There is a certain literature dealing with extensive records of dreams and even with experiments in this elusive and fragile domain, those of M. Claparède, of Geneva, for example. I have here also had the fortunate chance of being able to observe in such a manner as to get certain precise determinations, and it happens that whenever any such observations are brought in to test Freud's speculations, their falsity becomes evident.

Dreams are nearly always of very short duration. The question arises as to how it is possible, during a very short space of time, to dream of events that would require weeks in their actual occurrence. That question I have entered into as one of the corollaries that arise from the establishment of the Fundamental Processes, and the explanation removes the appearance of paradox.

Dreams are also nearly always concerned with something that happened recently, most commonly during the previous day, or the day before ; and they are generally superficial in character, and the incoherent associations that arise in dreams have, as a rule, no great mental significance.

I do not mean to say that nothing can be learnt from dreams ; on the contrary, I believe with Freud himself that details which are apparently of no great interest may often serve to throw a light upon the subject, if they be properly interpreted. The interpretation here is especially important.

The narrative of a dream may give a physician an indication of some pathological state ; as, for instance, those of the night-terrors of children. Dreams of struggle, of oppression, of falling from heights, and so forth, nearly always relate to certain conditions of the body whether of indigestion or heart-disease, as it may be in grave cases.

The study of dreams in this manner becomes a serious scientific work, but Freud's interpretation demands no particular knowledge, either of physiology or psychology ; it requires only the flourish of his jargon of technical terms and then at once a plunge into those characteristic details whether taken from the writings of Krafft-Ebbing or Bloch, or the spicy columns of the *Police Gazette*.

There is one side of Freud's system which might, in the hands of a serious investigator, be found of real value, and that is the region to which the term psycho-analysis should be more strictly applied. This system was not invented by Freud, for it forms part of the larger branch of experimental psychology, which took its origin in the investigations and observations of great value by men like William

Weber and, when he kept within the limits of reason, Fechner. Experimental psychology could never cover the whole range of psychology in general. It only gives precise indications with regard to what has been known and, to some extent, studied previously, but it is a subject which, once having gained vogue, occupies an extensive place in specialized classes of the Universities.

The professors are grateful to Experimental psychology, for it seizes upon the attention of the pupils, and gives them the impression that they are learning more than is really the case, for they might carry out experiments of this sort for years without discovering anything we do not already know, and without having a clear perception of the meaning of psychology at all. In this sphere, itself a branch of psychology, psycho-analysis is one of the modes of exercise.

One of Freud's disciples, Jung, has greatly improved on his master's suggestions in this matter, and he has presented us with something which, if it stood alone and apart from characteristic Freudism, might well be esteemed as a useful adjunct in the armoury of the neurologist. The theory, broadly expressed, is that if the replies to questions be analysed, they will be found to yield an indication of the state of mind of the person examined. If, for instance, the question be a somewhat embarrassing one, the answer will be longer in coming, and the

marks of hesitation may appear in the terms in which it is expressed. The answers require to be very carefully examined, but here, wherever Freudism enters, it tends to falsify the results because it introduces the bias of the examiner himself.

To give an instance of this : Jung, in putting a series of questions to a patient, gave the term 'Male Nurse' and, after a time, got the response 'Female Nurse.'

" Now you see," he says, in effect, " this answer reveals the preoccupation of the patient with a greater clearness than if he had made a confession. It is a case of sexual complex, inhibition,——" etc., etc.

It so happened that for another purpose and on another occasion I had tried a similar series. When the term " Male Nurse " was given me I tried to think quickly what it next suggested. " Nurse " suggested a bed with a patient in it, but I could not bring myself to mention either of these words, perhaps because they were associated with so many other different things. I next fixed my attention on the arrangement on the wall over the head of the bed where the patient's identity card and other things were kept, but I could not think of any precise name for it. Time was running on and I could get no answer ; then I thought of a whole hospital ward, with a vision of a nurse standing by a bedside and so, in desperation, I cried : " Female

Nurse." Here, then, there was a considerable lapse of time, and a hesitation, but the conclusions of the Freudian psycho-analyst on this ground alone were erroneous for, on this particular occasion, the Sex obsession, whether complex or simple, was entirely absent.

Except, therefore, in expert hands, the reading of the answers is apt to be illusory. The responses become oracular, though, as of old, that does not prevent them being interpreted in accordance with the inclination of the person who puts the question.

A psychological question of some interest arises in the analysis of the forces that launched Freud into fame.

In the first place, science has usually a severe, if not forbidding aspect. It is difficult to avoid this because in the very meaning of science is implied patience, concentrated thought, serious application of the mind to problems either often misapprehended or ignored; and it is not until one has risen from the immediate contemplation, and beholds the working of a subtle instrument opening up large vistas, that the glory of science becomes apparent. The severe aspect is often emphasized, especially in academic writing; but there again it may not be the writers who are always to blame. Fifteen years ago, as St. Paul hath it, I knew a man who spent years of study, reflection and experiment, in order to clear up the mystery of a psychological problem;

having arrived at the end, he next cast about for means of making this clear to the "man in the street" and therefore with avoidance of technical terms. But it was the "man in the street" who turned round and rent him; he looked upon this work as simple, and he felt offended that he had been deprived of the mystification he had a right to expect.

Freud has not made that mistake, and one can recognize his influence everywhere. There is not the most '*chestive cambrouste*,' which may mean the most delicate A.B.C. girl who, nowadays, instead of saying that she does not feel "up to the mark," but will state that she is suffering from an "inferiority complex"; and in other quite different regions where brains are in high activity and ideas freely exchanged, as for instance, at public-house bars, I have gathered that the populace, or, again, even sage Labour leaders, judges, doctors, artists, have steeped their souls in Freud. It gives an air of importance to describe some mental difficulty as "a hesitation complex" or an "erogenous inhibition" and the only thing left to the plain man is to ascribe the whole affair to a "kinetic drive" and to show the influence of the "herd instinct" on a "catastrophal diaschisis" emanating in a struggle (contest complex) between the homotactic impulse and the egocentric dyschezia.

Freud himself has understood all these matters perfectly; they are, when once you get into the

swim, far easier to understand than the elements of psychology; but even this will not carry him far. If only arguments bombasted out in the special jargon of the experts were required, the University professors might still hold their own. But something additional is needed—the tact, the manner, the atmosphere; it is these touches that show the master; and there Freud, to do him justice, scores.

But all this is insufficient. We have not arrived at the gist of the matter. The ordinary civilized young man or young woman is over-civilized, especially in this country, where fairly simple happenings are shrouded in an air of mystery, which produces, on the whole, a view of things more strained than would arise in the midst of sheer immorality.

In the old days of the glory of Greece, if a sculptor carved out a nude female form it was a nude female form, and that was the beginning and end of it. Nowadays, if an artist represents even in less convincing lines the female form divine, he calls it, "Truth arising from a Well" or "Hope," or "Faith," if the image be exceptionally pale, while Charity may be supplied by the onlooker who tries to believe these images masterpieces.

A witty French writer said of my old friend Rodin that, if he were asked for a memorial of Victory, he would sculpt out a pretty little dame showing her charms; if he were asked to produce a memorial for Science, he would sculpt out a pretty little dame

showing her charms ; if he were asked to produce a memorial of Peace, he would sculpt out a pretty little dame showing her charms. This was not entirely true of Rodin, a great and sincere artist who, in all his simple and unaffected appearance, regarded Art as a religion and himself, with due modesty but all devotion, as one of its high priests ; but something of the sort is true of Freud, except that his sculptural little pieces lack beauty and ideality. He has a certain little bag of tricks which, on every occasion and for every subject in turn, he throws on the table to commence the play. The most potent of these is the " Sex Attraction " and one can imagine the delight of the student suffering for years under the " Repression Complex " meekly approaching a work of Psychology in the spirit of a bad swimmer being asked to cross the Channel, and then suddenly finding himself not asked to think at all, but entertained, fed, prompted and gorged with most unexpected luxuriance of sexual lore.

Here again one is propped up with the question : Do you deny there is such a thing as Sex in the world ? And once again I answer : No, I do not deny that. But I deny that reeking talk of this kind is an equivalent of an exposition of science. The realism of Zola, for instance, has never given me a shock, except, indeed, when he departs from his realism and seeks to produce a conventional effect. But I would much prefer to have science

as science and, if my jaded spirits should require the other sort of refreshment, to seek for it frankly stated, as, for instance, in the works which once made the charm of Holywell Street.

But there we have the real driving force of the Freudian system. Here was a letting in of the waters, if you like, red ruin and the breaking up of laws.

The next strong motive power comes from the United States. Our American friends are the most audacious, the most up-to-date, the most imitative and the most servilely bound to our own played-out literary traditions, of any people in the world. Side by side with a high-strung, perhaps impossible morality, with that stern and uncompromising Puritanism which has given us the Prohibition Act and the noble army of bootleggers, they have the faculty of booming into fame works of no great merit, which have at least a strong popular side. Freud for them was an ideal author and, partly by reason of a high-strung spirituality, associated in the American mind both with blatant absurdity and a special high-pitched jargon ; Freud's works came to these half-baked minds like rain from heaven on a thirsty land.

It was a great financial enterprise, and any book which has a financial success may be sure of repercussion beyond its original intention. The Freud wave swept over these Islands and, boomed again

by the popular Press, it found at length entrance into circles which are usually extremely exclusive against even science which has not the hall-mark of a special trades-unionism—the medical papers, the medical journals, the British Association and the rest of that category.

It was amusing to notice in what a gingerly and hesitating way this subject, once introduced as a topic, was handled by some of our great scientific authorities. They seemed to be afraid to pronounce, either one way or another, they showed no faculty of separating the dross of popular appeal from the pure ore, if any, of science, and they simply played for "Safety First" and the salving of their own reputations.

Certainly there is nothing peculiar to our own times in all this for, as we have already seen, fashions in charlatanism come and go and, in a few years, the minds of the people, set perhaps upon another phase, or still more spicy attraction, will find Freud rococo, dead as Queen Anne or Aphra Behn.

Hitherto we have been in the world of reality, even with Freud. Now we come to a mystic realm, I had almost said a wonder-realm, except that that word conveys something of beauty and power.

I deal with the orthodox professors of philosophy.

One evening I hied me to the Aristotelian Society. There was a time when I used to attend its meetings.

There was a time when as the hart panteth after water brooks so thirsted I for knowledge, and when, at a signal that something might be found whether in the Ville Lumière or in the barrack-like capital of Hohenzollernism, thither I betook myself like a pilgrim who, forgetful of sack and scrip, is still fed by the wild honey of the ideal; I have traversed deserts of toil; I have lived hidden in deep and unregarded loneliness; but I have done more, and I dwell in the hope that the Recording Angel has of this taken note with the lurking intent of wiping out my sins—I have attended meetings of the Aristotelian Society.

On this particular night George Bernard Shaw was there. I was surprised at first to see him; it was as if a sinner who had been a scandal of the town were suddenly to march up to the Penitents' Bench, or like a Salvation Army convert describe in glowing terms his past lapses so as to give greater glory to his new-found state of redemption.

The fact was—what I did not know at the time—that just as Edison, who had been working with electrical devices all his life had in the end the extraordinary curiosity to read up something about Ohm's Law; so Bernard Shaw, who having amused us in his diablerie of wit, taught us in all sorts of cunningly thought out comments on topical subjects, but without great evidence of deriving from a philosophic source, had thought well to fill this lacuna in his system by studying Bergson.

But Bernard Shaw has too incisive a style and too mobile a spirit long to be held down by the drudgery of science. He had caught up Bergson's magic phrase of the *Élan Vital*, and the very sound of the words—for he was cultivating French and France at that time—(I shouldn't wonder but it was the *Élan Vital* that propelled him at length to Rouen and gave him his vision of the visionary Joan)—this blessed slogan, the *Élan Vital*, then, sank and fermented in his prolific mind. Bernard Shaw at that time was fed as with a divine manna on the *Élan Vital*.

Now it so happened that on that same night the main paper was devoted to a subject which, of itself, might have been attractive to Bernard Shaw, who is an extraordinarily serious man for those paradoxes that bowl the "flappers" off their chairs in laughter, are not taken by him so seriously, and he has a real capacity for practical business. Could I have been a dictator for twenty-four hours, or even a constitutional little Mussolini, I would have made Bernard Shaw an ambassador, and sent him to Berlin,—not New York, for his lambent wit would there shatter to pieces the extraordinarily conservative edifice which the disciples of Thomas Jefferson have so conscientiously built up.

However, it was not Bernard Shaw who was in the limelight that night; it was Bosanquet. He has now passed away, I regret to say, for he was a

kindly man ; and, on reflection, I am sure, that the philosophy of these philosophers has not only no relation to reality but has no influence at all upon their own, non-official modes of thought. I had myself, when I entered the room, a sort of weak anticipation that, having a practical subject, he might in the course of his paper emit some shrewd ideas ; I was interested, moreover because, being at that time in Parliament, I had acquired new lights on the reading of history ; I could see what were the motives which moved parties and produced Acts of Parliament ; and I had formed certain opinions as to the principles on which the constitutions of states have been compacted. And then I heard Bosanquet's speech.

O, Heaven, what an Address ! He was a Kantian, of course ; they are all Kantians, remote or near, who profess at the Universities, and the virus, however attenuated, has always precluded the sanity of health.

From the first he took flight. He waged a sort of intangible battle in starry realms. He talked what I thought at the time to be the most baphometic nonsense I had ever heard uttered by human lips. I had once, by the way, listened to my friend Miss Loie Fuller dilate on the Eastern Question. The Eastern Question was so intricate that it demanded the treatment of an expert, and Loie Fuller—was not she an expert ? She was a genius, and her

imitators have given us but a pale reflex of her beautiful self ; and, as Loie talked of the Eastern Question there swam through my mind a succession of dancing ideas, each more radiant than the last, flooded with iridescent and ever-changing colours, purified by flame and all bathed in the atmosphere of the high ideal.

Now, if Bosanquet had talked anything but nonsense, he might have been compared with Loie Fuller ; but nothing of the charm and light and colour were there. Nothing but Kantian transcendentalism and the vapid wheezings of the brain-wrecked professors.

I turned to look at Bernard Shaw and—it was one of the extraordinary experiences of my life—Bernard Shaw was sitting there, mute, and mild as a lamb. *Élan Vital* had tamed him, even Bosanquet's farrago produced no reaction of comedy.

However, I will not pursue this matter further now, for the respected professor has passed away, and no one ever reads a dead professor's philosophy. It is only the thinker—he who communes with Nature—to whom comes that pale recompense of leading the thoughts of men when the voice that might animate the words is lost for ever.

And yet when one reflects on the generations, centuries, the thousand years, during which the professors at the great Universities have wrestled with and wrangled on these problems, yet producing

nothing on which the mind could build, leaving a record the most appallingly barren in the course of human history, one would think that it might have been suggested once in a way that there was something wrong, in the methods at least. All this criticism is founded on the assumption that there is a science of psychology and that the science is worth developing ; that it is indeed essential to the complete understanding of the other sciences, and for a sane view of the application of these to questions of ethics. This proviso must be clearly understood.

Once in reply to an article of mine, in which I had stated something of what I now insist upon, a learned professor, and Principal of one of the great Universities, said, in an interview, that there might possibly be something in all this, but that the main function of subjects such as philosophy was to tide young men over the difficult years of their University course. I read these words so expressed with a feeling of stupefaction—not only that they should have been uttered, but that they should have been received by the public with approval. You see the learned Principal did not suggest that psychology or philosophy should be eliminated altogether from the curriculum ; every self-respecting University contains chairs of thought. But he implied—and this is really the gravamen of my charges expressed in another way—that the important matter was rather to beguile the attention of the youth of the

country by diverting it into paths that led nowhere; and therefore that, in a choice between books, one composed of mere goody-goody precepts or something entirely incomprehensible, and the other, scientific and illuminating and leading to wider vistas in the onward march of the human intellect; that it is this last work which should be discarded and discredited.

Once more I feel forced back to that reflection which I have expressed in aphoristic form: The only atheism is the denial of truth. And this seems to me to constitute a terrific indictment against the men who utter an apologia for false and delusive teaching. There was a time when I would rather have cut off my hand than have written such a statement as he gave forth; and if I would hesitate to do so now, I do not know, it would be due to the blurring of my ideals by that fog of hypocrisy and cant, which seems like the very air we breathe.

And yet I take heart of grace once more, and march onward, for I see more clearly the difficulties that beset one, also the poor and immoral principles on which the opposition is based. The world of thought appears to me as a magical land whereon one finds erected, like the castles of the robber barons of old, great fortresses buttressed and bastioned, formidable to the view, almost impregnable, from the battlements of which float the proud standards of falsehood. These are our Universities.

Once, I will not say in what city, when I was diligently working through my medical course, and, at the time, carrying out my duties as dresser to a great surgeon, the patient at the time being a handsome young woman whose internal organs were being explored ; at a certain moment, and *apropos des bottes* as far as I could make out, the surgeon turned round to me and, with his dripping knife poised on high, said : " Don't you agree that Arthur Balfour is the greatest thinker in Europe ? "

I heard the question with amazement, but after a pause, I answered timidly : " Well, I should have to begin by making certain reservations."

" What do you mean ? " my surgeon cried, and there was more truculence in the voice than implied in the words.

My future depended on his good-will ; but there are desperate situations in which even the worm will turn, and I replied : " I have read his books ; have you ? "

" Aoawh ! " he cried, " if you put it that way,—I have never read a line that he's written ! " And with that, as the young lady was quivering on the table, he turned contentedly to the job that he really knew, and, with a deftness begot of the butcher and the seamstress, quickly completed the operation.

The point of the story is that this man had standing enough and brains enough to have become President of the Royal College of Surgeons, and in

that office it is quite possible that he might have entertained Arthur Balfour at some important official banquet, and that, in his capacity as President, he would utter the words which had so disconcerted me, though possibly not knowing more about Arthur Balfour's writings than he did at that moment. These words would have been broadcast all over the world, and the world would have said : Science endorses Arthur Balfour's philosophy.

The world would not have known exactly what this meant, but the impression would have remained, and this is really the manner in which contemporary fame is generally created. Eminent men get together ; they bandy compliments like bouquets from one to the other and, though this be allowable and sometimes laudable, the effect is that they form a buttress against any new ideas that impinge on what they have consecrated as conventional and orthodox.

Another picture comes to my mind which introduces no less a figure than Bergson.

What are the marks of a great thinker by which he should be known ? He should certainly have great acumen, a keenness of perception to see subtle meanings ; but the critical faculty is not enough. That was the great *forte* of Hume and, in our day, of Bertrand Russell ; but this, though necessary, is not sufficient. There is required something of determined planning ; that is to say, not building up artificialities, but seeking the unfolding of mys-

teries so as to reveal the inner structure of things. There is a certain dynamic force wanted, a determined energy of progression ; something that corresponds to purpose, by which various strains of study are brought to some co-ordination in order finally to arrive at results of value.

I cannot find one University mind that responds to these last-mentioned tests. There is nothing to offend them in such a statement, for I have heard Green of Oxford glorified on the very grounds of ignoring these qualities. One of the Aristotelians laughed consumedly at the question of a student who wanted to know from Green : "What it all led to ?"

"I believe," said the professor in his amusement, "that he wanted philosophy to discover something!"

The amiable professor's idea was, and this he ascribed to Green himself, that philosophy should at length induce in a man a kind of Buddhistic contemplation, wherein the philosopher played with ideas and theories as an Eastern potentate might with jewels, admiring them here and there, not for meaning anything special, but for possessing pretty facets.

Judged by the standard which I have put forward, and after a re-reading of Arthur Balfour, I cannot find there the marks of any great thought at all. I read through long tracts of dissertation of his which give me no ideas at all ; they are the pleasant academic discussion of things expressed in smooth

academic language, and of this he is a master. There is nothing here to carry ideas with momentum, or with new lights to illuminate the vision.

Finally, when a man's work is over, he is remembered, if remembered at all, by something that he has said or done that no one else had said or done before him, and if it be of value, that stands to his credit. Arthur Balfour has been Prime Minister; he has been loaded with honours, and though I believe that these adjuncts are of enormously greater value to contemporary reputation than any power of thinking, they do not produce permanent fame. Others have been through that same course, and nearly all are regarded as mediocrities. Looking over Arthur Balfour's writings, I find one essay which is really superior—that on Berkeley,—where the subject is precisely one where Arthur Balfour might display his erudition, his academic wit, his graceful touches of lambent allusion, and a certain refined, artificial but, of this genre, pleasing style.

In the same line of thought I believe that Carlyle will live, not for his histories, which have been done better by others, or for his social reforms, for he had no practicality of mind and no touch with the people, but as a wit and a character, and with "Sartor Resartus" as his testament.

But to return to M. Bergson, not that I had lost sight of him, but because it was necessary to surround him with pomp and circumstance, and a

philosophic atmosphere. The dais on which he stood was crowded with notable figures, rendered the more notable by the gorgeous uniforms, the silks, satins, purples, and feminized draperies which delight the souls of the scholastic caste.

Then at length M. Bergson rose to speak. A figure of medium height, slight and frail, surmounted by a head of good appearance, the features fatigued with the toils of the study, and an expression in which he did himself injustice by repressing the natural mobility of his countenance. The voice was high-pitched and thin, but, in that solemnly hushed atmosphere of the philosophy theatre, it sounded with a strange Maeterlinck-like intonation. He had no sooner begun to speak than the entire audience seemed to bend as one person, commencing to take notes. As the discourse proceeded, he gave utterance to many thoughts which were commonplace enough ; he threw off paradoxes of which it was difficult to seize the meaning ; and then, once or twice, he almost startled me by saying something that indicated a deep insight and rare powers of reflection.

With all this, however, there was no coherence, no sense of proceeding from an established base by cogent reasonings, no organic development. It was a characteristic Bergsonian discourse.

His books show the same qualities. He is a deeply-read man, he has a far greater acquaintance

with science than most of his confrères ; but if the structure of the work be examined, and if, as in the case of Spencer, we apply a dissecting scalpel to separate the accidental or the artificial from what is a cohesive organism, we find that this display of science is merely ornamentation. Apart from his spangly phrases there is little philosophic teaching at all. Certainly there is a sense of literature, but separating the two effects of science and literature, I would seek my literature somewhere else ; I would prefer, for instance, to read the *Arabian Nights* ; or, if I must be confined within academic limits, I would feed on this sort of ambrosia taken from a book called *Human Life and the Body*, by A. Rabagliati, M.D., F.R.C.S. :—

"When the time arrived, when all things were now ready for the occurrence of the mutation, the force of man-life appears to have procreated the human form, whether black, yellow or red or white, at all ages and stages simultaneously, specimens of both sexes appearing or arising as old, middle-aged, mature, adolescent, juvenile, infantile and unborn simultaneously. . . . Man is the incarnation of anthropino-zoo-dynamic or man-life. Man-life is distinguished from horse-life or hippo-zoo-dynamic."

You may say that, although something real might be fished out of all this, it sounds like bobby-dazzling incantation.

Well, that is what I say about the *Élan Vital.*

Bergson's great exponent in this country is Professor Wildon Carr, but, rendered in cold English, with the somewhat matter-of-fact associations of our

language, the magic of Bergson is gone, and with that all is gone. I do not recommend these books. Take this, however, from a paper of Wildon Carr, delivered from the Presidential Chair of the Aristotelian Society. It is a sample of academic writing, without magic :

"What happens, then, when a totally new sense-presentation arises? How can it bring with it an againness for the mind to enjoy? It sounds a paradox. My theory of the mind gives me the explanation. Recognition is the form which prior recognition gives to new experience. The mind receives the new presentation into a ready prepared organization of past knowledge and incorporates it. Recognition is the expectancy with which the mind grasps the novel, the unknown, the unforeseen. By this I mean not only that recognition has prospective value—the whole attitude of life is forward-looking and all value seems to be prospective. I mean more than this. The past, as from being present it becomes past, gives form and substance to the present activity and is carried along in it. It is this incorporation of past experience in present activity, and not repetition, and also not resemblance of present experience to past experience, which constitutes recognition. And this explains why and in what way all cognition is of necessity recognition."

Associated with Professor Wildon Carr, especially in the Aristotelian Society, is Mr. Dawes Hicks. They were, if I recollect aright, the main decorative figures on the dais from which M. Bergson pronounced his memorable discourse, which, if it did not illume the path of man, yet served indirectly to enhance the reputations of his supporters.

Mr. Dawes Hicks is a respectable Cardinal of Thought, both in ability and temperament. He

has all the qualifications of a thinker, that is to say, he occupies a high position in the Hierarchy, for he is Professor of Philosophy at University College; he figures prominently at Academic functions; he never emits a sentiment which is not a smooth endorsement of the official conventions; he stands at the portals of the manufactory of reputations, for he has helped to run the Aristotelian Society, and he is, I believe, assistant editor of "Hibbert's."

"But you spoke of the qualifications of a thinker?"—Yes; but is not that already sufficient?

If a young man came to me, in the innocence of youth, and with wondering eyes cast upon a mystic future, I would be constrained to regard him with the utmost attention. If I saw there fine features of strong but delicate mould; well-shaped, beautifully arched head, such as Fresnel or Abel, or Keats possessed; an eye of genius in which intelligence glowed, backed by a glance that spoke the hero's blood, I would say to him: "Good God, unfortunate young man! Had you not thought better to have aspired to be a camel-driver in the desert! Your constitution is a little worn with toil of thought, but with training you might still hope to be a sailor before the mast. You might break stones by the wayside in Australia."

He would look up to me with eyes of sad amusement; he would say, "I want to be a Thinker!" And I would feel inclined to clip him to my soul

with hoops of steel, knowing, in my admiration and my sorrow, that he was preparing for himself a Calvary in which, at the end, he might be inclined to cry: "O my God, my God, why hast Thou forsaken me?"

There have been such in the world, and they seem to me to bear the promise of the redemption of man, but they have purchased that distinction with something more precious than the breath of their life.

If, however, the aspiring thinker were a youth of another type, undistinguished in features, contracted in mind, with an expression in which a sort of "get-there" impudence allied itself with a time-serving disposition, I would say—though this time without warming emotion—"Ah, you can hope! Begin early to make that your profession, and begin early also to cultivate something odd and distinctive of style, which, at the same time, is strictly within the bounds of etiquette. You need not go to the extreme of Tolstoy's rough peasant blouse, worn over an aristocratic suit; and still less Walt Whitman's homespun dress, for that is hardly *outré* enough to secure you attention and yet is sufficiently off-colour to exclude you from good society. Select your University, not to learn anything, but to make influential friends. Speak frequently, but with a certain mannered delivery; never hesitate to bore your audience, for otherwise you will not be taken

seriously. Be diligent in class, not to think and ponder, but to acquire the special manner of utterance that distinguishes philosophers. You may, if you like, be daring, and even original, but always, remember, within circumscribed lines. Reproduce the teachings of your teacher and you will pass with flying colours. Come early to London, and seek to run either a philosophic society or, what is still better, a publication. Use tooth and nail and every combination you can think of, of flattery, of pressure, of squirming, to win a title. Then—but there I take leave of you. You are made."

In all this I have said no word of Thought in itself. No ; I leave that there also.

Now I remember I was speaking of Mr. Dawes Hicks, and, after this little divagation, I return.

I was searching for something to quote from him, but he has had the prudence to write little. Listen to this, however, on the Resurrection, in a laudatory preface to a work devoted to a certain once famous Dr. James Drummond :—

> "In the first place, the primitive attestation is itself by no means clear, and there are manifest traces of vacillation of view. The body which at one time has flesh and bones and is capable of being handled seems at another time to lose these characteristics. It appears and disappears in a mysterious way and finds no barrier in closed doors. . . . Whilst, then, rejecting the view that the dead body was restored to life, Dr. Drummond was inclined to explain the appearance, not as the offspring of fevered imaginations, but as self-revelation, made in some way we know not, of the immortal Christ."

When I read words like this, the shades of an indefinable, almost expressionless sadness steal upon me and envelop my spirit. Perhaps that is one reason why I do not quote further.

But do you think that Dawes Hicks lost the consideration of his fellows when that book appeared? No. On the contrary, his stock went up. Had he not been capable of writing in such a strain, had he not shown the qualities corresponding, he would never have risen to his present height in the world of thought.

I was about to leave him when just one other little touch caught my eye, also from the Drummond book:

"In particular, as the outcome of very complete and exhaustive examination of the available evidence, we reach the conclusion that the Logos, as Philo conceived it, was not a distinct personality, but the thought of God, a mode of the Divine Essence, which, while a characteristic indeed of the Infinite Mind, was also planted out and made permanently objective in the order of the Universe."

I will not continue, for in order to taste the wine, it is not necessary to swallow a hogshead, but if the reader feels encouraged, I invite him cheerfully to get the book for himself; if he does get a headache he will be able to say next morning, like the traditional Irishman, "But, faith, perhaps after all I didn't drink the whole hogshead."

I had at one time thought of entering into Bradley, but he, too, has now passed away, and I have but to repeat my former saying about dead professors. I am only interested in him in one point, and that

is that it was through Mr. Ramsay Macdonald's influence that he was decorated with the O.M.[1]

Now if this fact be linked on with that which I have touched on of my surgeon, with scalpel poised, dilating on Arthur Balfour, one has additional evidence of the manner in which reputations are made. I cannot think that Ramsay Macdonald has ever made deep study of philosophy, for the consecutive pursuit of a principle does not seem to accord with the temper of his mind. But all this shows the overwhelming force of orthodoxy. For Ramsay Macdonald, pictured to many as the bold champion of an on-sweeping Democracy, has here shown himself bemused by the very phantoms of convention, his mind caught and dazzled once again, if not by Conservative principles, at any rate by the idols of Toryism.

When we meet with Bertrand Russell, we find contact with something of a greater calibre. Hitherto we have been dealing with what old Milton in his wrath called "Tame villatil fowl" but which I, in a milder mood, my pristine vigour dulled by usage, simply describe as the bureaucrats of the department of thought.

That word, when I come to think of it, explains

[1] Mr. Ramsay MacDonald has informed me that the O.M. is strictly within the Royal prerogative; nevertheless, while Prime Minister he extolled Bradley's philosophy to the skies, and for that wanton and wicked act, and despite my high admiration for Ramsay MacDonald as a man, I allow these lines to stand.

much, for it calls to mind the bureaucrats of a still more official type. One of the great Ministries of Whitehall, for example, which has been instituted to carry out some great public function, only finds itself happy when it has no history. That is to say, bringing the matter down to hard pan, when it does as little as possible, even though thereby it be guilty of a betrayal of a public trust. If a Minister, for instance, wished to do something to eliminate tuberculosis, he might inspire himself with the thought that tuberculosis can be extirpated from our social system, and he might prick the sides of his intent by having it reiterated on every occasion that tuberculosis claims more victims in the world than the devastating wars which excite the horror of mankind. If then, such a man had a remedy to hand, he should apply it.

Ah, but there's the rub! For, look you, if he proceeded to apply the remedy, he must have bent his intelligence so far as to understand what he was doing; and as the very best measures in the House of Commons when they touch, near or remotely, some vested interest must run the gauntlet of a fierce attack, the Minister should be there in his place to defend his measure, with power and courage; it is quite possible that so much trouble would be made that the other members of the Cabinet would press for his resignation; but even if he stepped out he would at least have done his duty.

But turn to the other picture. If he does nothing of these things at all, if he does not seem even to interest himself, or at any rate to exert himself; and if, when the matter is pressed upon his attention from the outside, he reads off at the Treasury table one of those smooth, non-committal but virtually lying little documents which officials soon acquire the art of preparing, he holds his own, even in the esteem of the House.

Having occupied a great post with advantage, he is eligible for a higher one. Such a man may finish up as Prime Minister. He may be even buried in Westminster Abbey, and he may be worthy of all that monumental praise of the negative virtues which form the grace of tombstones.

The same is true of all the Departments, but most of them have to do with material things where the wound, though severe, is not mortal. "What is a million pounds?" I once heard Rodin say, "one man has it in his pocket in the morning and he goes to the Bourse, and another man has it in his pocket in the evening. What has changed, of importance? . . . But a work of art! Ah, there is the immortal thing which cannot be transferred and cannot be imitated!"

It was not often that I had heard a million pounds spoken of with such easy detachment, and I was pleased. And I concurred in all he said about the work of art.

But there are higher things even than that. Higher things even than the health of the people ; the Mind of the people. There we touch upon the sensitive nerve of creation. There we find the principle which means advance, progress, richer reality, greater scope of life, the Ideal. What then of the bureaucrats who smother this delicate principle of life ?—They dominate the British Association.

Speaking now of Bertrand Russell, we come in contact there with a mind of great activity and power, but the high respect in which I hold him must not deter me from criticizing his work. The most impressive of his volumes are those of the *Principia Mathematica*, of which the volumes, by the way, are three, and weighty. They were once mentioned to me by a French mathematician, who has also passed away but whose very name I cannot think upon without affectionate regard. He counterbalances all that I have said of the shortcomings of that genus, or of what d'Alembert has remarked of their " dryness of soul."

He said that he had been reading this *magnum opus* of Bertrand Russell's but that when he had covered one hundred and fifty pages, not without perplexity, and come across a remark that showed that he was approaching real numbers, he closed the book.

" Ah," said I,—" and who was the author ? "

"Oh," replied my friend, smiling indulgently, "*c'était un inoffensif.*"

I laughed consumedly at the thought of our great Bertrand Russell, this champion flashing his sword in the foremost line of progress, being set down so charitably as an "*inoffensif.*"

Moreover, it was not just to Bertrand Russell. His later books, especially,—and I say it even where I do not in the least agree with their conclusions—make one feel that there is in them a mind of power and purpose at work. His earlier books, and those that are more strictly philosophic, cannot claim that praise. They all have that hall-mark of the Academy, as of a painter who has diligently imitated for years the style of a master himself devoid of inspiration. Of the qualities which we lately considered as those of a philosopher, he lacks structural form and dynamic impulse.

This particular work, *Principia Mathematica*, I have endeavoured again and again to read without success, just as I have endeavoured again and again to get through books, which I feel must have a real value—Bunyan's *Pilgrim's Progress*, *Wuthering Heights*, and even *Dombey and Son.*

This is not entirely due to lack of courage, for I once spent two years on a half-page of Clerk Maxwell. I found that in order to understand it I must learn something of Quaternions and of Differential

Equations, of which at that time I had only a glimmering. These subjects, and others which they again in turn suggested, occupied me more than two years of diligent reading. But I knew that Clerk Maxwell had something of value to say, and that the labour was worth it. What is life, but to toil? Happy if we can turn that toil into something of the zest of an athletic game.

Now the intention of the *Principia Mathematica* was so interesting to me that I would have spent six years upon it, if I thought that in the end my mind would have been strengthened. But I do not think this book is properly based. Mr. A. N. Whitehead, who is one of the authors of this book, is a man of great ability, but a noble mind has been here overthrown by reason of a wrong conception of psychology. Both he and Bertrand Russell have fallen into the almost inevitable error of academicians of turning, as if there were no other possible path, to the dreary records of academic sterility. If they had been able to tackle the problem in the light of the Fundamental Processes of the Mind they would have produced a book of value instead of the big tomes of dead material built up of barren conceptions. Nothing, I repeat again and again, can ever be accomplished of high value in regard to the Principles of Mathematics or Psychology unless the Fundamental Processes be explored and understood; and, as I have shown in complete

demonstration, there is only one route by which these can be reached.

I will not enter into the detail of Bertrand Russell's later books except to say that he seems to play too much with paradox ; using a brilliant mind to reach conclusions which are simply disconcerting, as, for instance, where he argues on the maleficent qualities of science.

Better known than Bertrand Russell, one of the great popular teachers of the day indeed, is Dean Inge. I am not concerned at the moment either with his religious opinions or his political views ; I take him as a philosopher. He was elected President of the Aristotelian Society, and at a special meeting which gave it more than ordinary importance he delivered an Address on the subject : "Is the Time Series Reversible ?" His great discovery on that occasion seems to have been that if a man counted the buttons of his waistcoat from top to bottom, he could also count the buttons in a picture of his waistcoat from bottom to top.

Dean Inge did not express the matter by this homely image, and this perhaps was lucky, for if he had done so he might have hesitated to give the lecture at all ; but when his verbiage is stripped of its pompous terms, and the matter beheld, as we should always aim at in matters of thought, in the simplest manner, that is what it all amounted to.

Here, however, I will give a fairly long sample

of the good Dean's elucubrations in this same Address :

" The Stoics were right, I think, in denying that a continuance of success once achieved should affect our estimate of a man's career. Once again, it is a logical or rational sequence, not a temporal succession, on which we pass judgment. Has the meaning or purpose of a life been duly expressed or not? Sometimes we feel that a life has been incomplete. This is to appeal from the whole career as expressed in time to the timeless self, to which a short earthly course has, in our opinion, not done justice.

" It may further be asked whether the argument which I have been maintaining as possibly valid does not make all Change illusory. But the idea of Change, as Bradley has shown, will not bear examination. It is only true as negating a staticism which would turn the Time-series into a second and incomprehensible spatial system. When we speak of Change, we only mean that Time is not the same as Space.

" To a Platonist it is most natural to suppose that Time, in which all things pass, is itself timeless, in that it does not pass. It has been called the moving image of eternity; its perpetuity, for it has neither beginning nor end, is a symbol or copy of the permanence of eternity. Succession is the form of the world of Time; in eternity there is no succession, but the whole is always and everywhere present together. According to Plotinus, 'Time is the activity of an eternal soul, not turned towards itself nor within itself, but exercised in creation and generation.' The whole of Time is the life-span of the Universal Soul; 'its course is composed of equal, uniform, imperceptibly progressing movements.' More limited activities, representing Ideas in the mind of God, are spread out over as much Time as they require. It is because these are all subordinate to the life of the Universal Soul that we need not admit the possibility of many time-systems. The same philosopher says that Time is the 'measure of some definite limited activity directed to some end beyond itself.' Ends are pursued in Time; but there are no ends in Time, which swallows its own children."

There may be people who can find in this some grain to get under their mental tooth, but if so, I have only to wonder and to bow to them in admiration, for it fills me with mental ventosity.

What is the prescription for an academic discourse?

A professor has to write on some subject. It may be Memory, it may be the Doctrine of Heredity, it may be the Immanence of Evil, it may be the thesis expressed in the question: "Do Walls or Men Make Cities?" or "Do Shrimps make Good Mothers?"—the procedure is always the same. He looks over his well-stocked library of books which are themselves for the most part imitative and, whether he reads profoundly, or dips in here and there, it does not seem to matter, for he uses the names as pretty pieces of broidery; he quotes and he disserts; he disquisses of many things devoid of meaning with a pretty play of academic wit. And then, with all that, he strings together a passage of this kind; in which, whatever be the strength of the mind, the prejudices are not weak, and where spangly names glitter in a dilute verbiage which takes the place of continuity of thought. I get this from *Christian Mysticism*:—

"The problem among the speculative writers was how to reconcile the Absolute in Philosophy, who is above all distinctions [1]

[1] 'Deo Nihil opponitur' says Erigena.

with the God of religion, who is of purer eyes than to behold iniquity. They could not allow that Evil has substantial existence apart from God, for fear of being entangled in an insoluble Dualism, but if Evil is derived from God how can God be good? We shall find the prevailing view was that 'Evil has no substance . . .' . . . .

"The Divine nature, in other words, is that which excludes nothing, which contradicts nothing, except those attributes which are contrary to the nature of reality; it is that which harmonizes everything except discord, which loves everything except hatred, verifies everything except falsehood, and beautifies everything except ugliness. Thus that which falls outside the notion of God, proves on examination to be not only unreal, but unreality as such. But the relation of Evil to the Absolute is not a religious problem. In our experience Evil exists as a positive force not subject to the Law of God though constantly overruled and made an instrument of good."

When I read words like these I feel that if, whether by insidious atavism, Lamarckian usage, or Darwinian environment, I could ever be brought to write such lines, I would pray that in preference some surcease, not all too painful—for life would then be too petty for sacrifice—but profound, should still my spirit at once and for ever.

Dean Inge has of course been irresistibly attracted to Plotinus, the most obscure, and the furthest from earth, perhaps one could say from human reason, of all the belated followers of Plato. Here is a sample:

"The great difficulty, how to account for individuation, is lessened when we show them of the individual forms. . . . We are limited not so much because we are distinct individuals, as because we are half-baked souls. The perfect man would not be

less perfect because he lived in a particular century and country. A broad mind would not be cramped by a narrow sphere. We should not be wiser if we lived in a dozen scattered objects. It seems to me that when Bradley finds finite centres 'inexplicable' and is driven to say that 'the plurality of souls in appearance and their existence is not genuine' his difficulty is caused by his theory that the Absolute divides itself into centres, which is surely impossible. The notion that all individuals are (as it were) shaken up all together in a big Absolute, thus neutralizing each other's defects, seems very crude."

I have here a confession to make. There was a time when I was capable of sitting down and pondering in order to discover some meaning in these phrases, but the pity with which I regard that former self, I now extend to those unfortunate youths whose minds are conscientiously drenched in literature of the sort. To say that this kind of thought and writing reminds one of the Dark Ages is not a correct representation of the matter ; there has been no progressive evolution at all ; these are the Dark Ages.

Note, too, the citation of Bradley, and the peevish way in which these academic philosophers refer to each other's shortcomings. He says that Bradley is crude. There again, as in all things, I disagree with him. The word 'crude' has some association of substance, the defects which it indicates are immaturity, want of culture, freedom from sophistication ; but it has required a long process of continuous falsified teaching and chasing after

shadows to have induced men to entertain such thoughts as these—of a remoteness from reality that terrifies me—and in cold blood to set them down.

Subtle thoughts, you will say? Are they really subtle? Were the Sophists really subtle when they proved that there was no such thing as motion—because at a certain moment a body was in a certain place, and as the motion was the same at every moment, then at any moment there was no motion, for motion implied change of place.

Were the Schoolmen really subtle when they disputed violently upon the number of angels on the needle's point? Experience teaches us that it does not require subtle brains to discuss such problems. The student of Gibbon will remember how in Byzantium the bath attendants, corresponding in mentality to our pot-boys, used eagerly to discuss fine points of Consubstantiation and Transubstantiation, though without definitely establishing either.

In my eager search for something solid to lay hold on, I was attracted certainly by the 'half-baked souls' which, in my distracted mood I heard read out, and misinterpreted. But even there I was cast down. 'Fried soles' would have sent my mind skipping along in happy memory with visions of limited but honest beings in the New Cut on a Saturday night, but 'half-baked souls'—no. I was as much shocked by the turn of

thought as by the argotic levity to which the Dean descended, perhaps in a pathetic endeavour to dissipate his gloomy reputation.

If an ardent student really wants something extra subtle, or something, as Byron said, "craggy, to break his mind on," he will find abundance in the realm of science itself, for here scientific men themselves are accustomed to slur the difficulties. Let him try, for instance, to form a clear idea of what is meant by 'quantity of heat,' as apart from the indirect results which permit us to measure it. Let him investigate completely all that is implied in the use of 'Imaginaries' in mathematics; or let him tackle the task of establishing the theory of the expansion of functions in all its completeness, so as to show how Taylor's Theorem in a well-ordered development might arise as a case of a general formula; or, in psychology, let him answer the question as to how many objects of attention the mind can entertain at one moment.

These, moreover, are not idle questions. On their solution, each by each, depends a theory destined finally to resound in material corollaries of value.

I turn from the good Dean to Professor F. Schiller, who belongs after all to the same genus. One does seem to find here breath of reality, the sense of the eyes and ears of a live man, talking about things that exist; but after all he belongs to a caste,

and he verifies all that we have a right to expect from it.

There again is it not amazing that, after two thousand years of beating the air, with a final end in futilities, not one of these so little adventurous minds has ever dreamed of trying to break through the narrow grooves that have bound and atrophied their souls.

Too often in Professor Schiller we meet passages of this sort :

> "An alternative way of regarding this region of incomplete belief is to conceive it, not as mediating between belief and disbelief, but as constituting a field of *doubt*; but this will imply a change of attitude. For, unlike the decisiveness of full welcome (belief) and of definite rejection (disbelief), doubt has nothing definite about it: it is essentially transcendental; mobile, fluctuating."

Note here the underlining of the word 'doubt.' That is not mine but Professor Schiller's stroke of art. Italics are dangerous weapons, they indicate an excitable temperament, and when they insist on holding the attention to such phrases as that just quoted they indicate also a want of judgment.

Doubt? A friend of mine whom I once thought half-witted, I see now to have been a philosopher of arrested development. He was a lawyer in the little town where I was born, and when a youth was had up before the Justice of the Peace—who, as it happened, was my father—he put this subtle point : "The law says that one shall not cut a

sapling. This young man, it appears, has cut several saplings. Does the singular include the plural ?"

I seem to have heard that query reiterated all my life, or something equivalent of the same degree of sapience. If sometimes, like Figaro, as I have said, I laugh lest I should weep, yet there are times again when I feel intensely serious. When I reflect upon the striking experiences that I have known, those that are most insistent in their evil are not always the events of horror—

> "Immediate peril both by land and sea"—

fire and waste and slaughter; these are apparently the lot of our human life ; in "our strange and motley march from shore to shore" we strive, we suffer, we endure, and if we have fought a brave fight, something good may arise from the ruin that has been left of us ; but sometimes I feel my nerve strained beyond its power, when I see—a schoolmaster leading his flock or behold a professor marching to his chair ; for then I have a vision of the most precious thing in the world being distorted, defaced or seared ; that is to say, a rising young intelligence, honest in its intent, being held in constraint, and deformed with the remorseless little hammer-taps of the schoolmaster, and then afterwards deluded and cheated of all chance of redemption, when it appeals as a suppliant before the Court of the Cardinals of Thought

CHAPTER TEN

VITALISM

VITALISM is one of those subjects which come into vogue periodically, the force of the fashion depending to a great extent on the ability of the representative of the cult.

At one time Vitalism appears to have been universally and tacitly accepted ; it was a point of religion ; and its successive revivals have been due also to the influence of a certain religious idea.

Some years ago I heard in London a lecture delivered by one of the most famous of the Vitalists, Hans Driesch, who had the advantage of a wide knowledge of biology, derived in part from his own experimental work. It was instructive to listen to Hans Driesch, for whenever a man speaks on a subject which he has studied all his life, whether biology, or newspapers, or the trade in pickled eels, he rises to heights of poetry ; but in Hans Driesch's discourse one point seemed to be missing—and that was the essential. He spoke to us of biology, and he spoke to us of vitalism, but he nowhere showed the nexus between the two.

What we expect of the vitalist is that he should demonstrate to us certain processes which take

place, and in which some one, or all of the steps are inexplicable in terms of the laws which govern inorganic matter. No vitalist has ever done this. They have talked either of vital force or some guiding principle, which Hans Driesch calls entelechy. The vitalist theory invariably contains certain obscure passages, and it is in these shadows that it becomes associated with phenomena which are really separate from it, such as spontaneous generation, purposive design, or dogmas of religion.

Mr. Benjamin Moore is another savant who speaks on a basis of a wide extent of observation, in those regions where the study of inorganic chemistry and that of organized form become extraordinarily interesting but, like Hans Driesch, Benjamin Moore contents himself with giving us, in place of a demonstration, a convenient expression which he calls biotic energy :

> "The conception, in brief, is that biotic energy is just as closely, and no more, related to the various forms of energy existing apart from life, as these are to one another, and that in presence of the proper and adapted energy transformer, the living cell, it is capable of being formed from or converted into various of these other forms of energy, the law of conservation of energy being obeyed in the process just as it would be if an exchange were taking place between any two or more of the inorganic forms."

Some few years ago a French biologist, Stephane Leduc, created world-wide interest by a series of experiments which, as I now express them, do not seem to belong to the "sensational" order of

phenomena beloved by the daily Press. He showed that if fragments of calcium chloride be dropped in solutions of alkaline carbonates, for example, there ensue a variety of growths which suggest corals or polypi, or other lowly forms of life. At the time that he attained these results Professor Leduc was endeavouring to imitate by artificial combinations the structure, or at least the outside envelope, of a living cell. He was himself astonished at this growth of forms resembling living organisms, and he drew the attention of a friend to these products, and the story found its way into the newspapers.

A good journalist, however, is more of an artist than a man of science and, on the somewhat slender foundation of M. Leduc's results, there was built an astonishing and glittering fabric that sent its glinting rays to every corner of the globe : Stephane Leduc had fabricated Life !

No one was more astonished than the enthusiastic, but yet modest and conscientious man of science, from whom this Arabian Nights-like story took origin. He had not really produced living beings at all, but had shown some noteworthy forms of crystal systems.

Sir Ray Lankester deals with this subject of vital force in one of his thoughtful and lucid papers. In the course of it he quotes Herbert Spencer's Definition of Life :—

"The continuous adjustment to internal to external relations," and he adds: "this implied that what is called 'suspended animation' was not really a possible thing, but that there could only be an apparent or approximate suspension. On the contrary, it seems that, just as when they stop a watch by holding back the balance-spring with a needle, and yet not 'kill' the watch, for it will resume its movement as soon as the needle is removed, so the changes of the chemical molecules of protoplasm can be arrested."

Sir Ray Lankester's conclusion, in opposition to Hans Driesch, is that it is not necessary to suppose that a 'something,' an essence, a spirit, an intangible existence, called 'life' or 'vitality' or the 'anima animans,' passes away or, as it were, evaporates from a thing which was living and is now dead.

Professor J. B. Leathes, in a lecture at an International Conference on Physiology, joins issue, though not very violently, with Sir Ray Lankester, first of all with regard to 'suspended animation,' of which he says it is a question whether this is anything more than a retardation to a rate obtained that is imperceptible by the ordinary methods of observation. He says, and no doubt truly, that the two phenomena of the growth of crystals and the growth of living matter, are "inconceivably different." The peculiar thing about the chemistry of living matter, he believed, was not that its characteristic reactions were modelled, but that in the "rough and tumble of ordinary aqueous systems, their occurrence was almost infinitely improbable."

He concludes that there is a fundamental distinction between matter in which life is manifested, and living matter, though he does not expressly adopt Driesch's Vitalism. He is circumspect and restrained, except indeed in his final passage, which is worth giving if only for its poetic afflatus :

> "It may be that in the lifetime of some of us these confluent streams of thought and experiment are to be joined by yet another that rises in the vast, remote and, as it must appear to some, muddy swamps of physiological chemistry; and it then, forgetting its 'foiled, circuitous wanderings,' will form with them a 'majestic river, brimming and bright and large.'"

M. Kubierschky, in a lecture to the Society of German chemists in 1913, comes to closer grips with the problem by showing the nature of the reactions that actually take place in the inorganic and organic spheres, and he indicates that there is no new principle introduced in the passage from one domain to the other. The lecture, though extraordinarily interesting, is too technical to permit of quotation.

Then we have that remarkable man, Dr. J. S. Haldane, who has shown moral courage on more than one occasion already, as, for instance, in the remark of his we have cited with regard to Carnot's Heat engine. He holds a middle view between the Mechanists and the Vitalists. He says that the Mechanist asserts that life can be explained in terms of matter and motion in accordance with the chemical,

physical or mathematical laws known to us ; whereas the Vitalist holds that some obscure vital principle or force is at work to regulate the processes, chemical, physical, or what-not, that result in what we all recognize as Life. He finds neither theory acceptable. The living organism as a whole would seem to regulate its internal environment with extreme delicacy, and no less to regulate its external environment so far as it can ; yet, given change in the latter, it exhibits great powers of adaptation to the altered circumstances, even changing its own structure by preserving its identity and characteristic activities.

On the whole I find myself in agreement with this expression, as I shall indicate a little later, but in the meantime as I have manifested my admiration for Dr. Haldane, it may be expected that any criticism on my part of the conclusion of his paper is not motived by prejudice. He was speaking at Yale College in 1915, in the course of the Silliman Lectures, and—was he carried away by deference to this excellent patron ?—he launches out into an extraordinary discourse of a kind that I have come to associate with professors.

As poetry to the inspired bard, or strong drink to the honest sailor-man on shore after an arduous voyage, so these excursions into the realm of phantasy seem to appeal to the academic mind after too long and strained a contact with facts.

"Conscious personality," he says, "is far more than mere organism, and the conception of life is just as inadequate in connection with personality as are the conceptions of matter and energy in connection with life. Biology, dealing with living organisms, has for its material an order immanent in the natural world that is far above the order disclosed to us by the study of the inorganic world. Can biology help us in the search for evidences of the presence of God in the natural world? No," says Dr. Haldane; "it is not from the data of biology, and still more clearly not from those of the physical sciences, that we derive our conception of God, but from the facts of knowing and consciously doing which we observe in ourselves and our fellow-men as conscious personalities. It is the perception that in us as conscious personalities a Reality manifests itself which entirely transcends our knowledge of God. It is in the world of duty and knowledge, not in the natural world as such, that we find the God whom our fathers have worshipped, and in whose strength they have been of good courage and faced trouble, danger, and death. In losing our individual lives we find our true life, and in no part of human activity is this losing of the individual self more clearly realized than in scientific work."

A passage such as that just quoted often sounds impressive, and seems to bear with it a certain spiritual quality, simply because the author brings in terms with which a certain reverence is associated, but there is no real connection between this particular mood and the arguments for mechanism or vitalism out of which it arose. To weigh on our judgment, therefore, in a philosophic discussion with influences derived from another source, which are thrown in either by way of prejudice or of persuasion, seems to me unscientific and wicked.

In a book of Dr. Haldane's, *Mechanism, Life and Personality*, he pursues the same method, introduc-

ing matter which only by an accident of our civilization can have even a remote connection with questions of science. He here follows the sacramental etiquette in citing Kant and, with him, being a Scotsman, of course Hume. His argument against materialism tells us solemnly, as if it were an outcome of the Kantian philosophy, that, " all are part of one inseparable whole " and on this text he proceeds to elaborate in the usual approved style.

Remembering what we have already observed in regard to Kant's philosophy, in the first place that Kant's list of Categories is both redundant and incomplete, that there was no clear conception in Kant's mind as to the real import of these Categories, and that his philosophy was not really developed from that basis but rather preconceived and joined on to a subsequent, tentative searching for the Categories, we will be better able to appreciate in what spirit Dr. Haldane quotes these authorities, and how inferior such passages are, with regard to clearness of vision and cogency of argument, to the parts where he speaks with real knowledge of the details of physiological experiment. I cite a passage at some length as one of the best examples of academic thinking at a high level, which seems to me only saved from the evidence of its own hollowness by the obscurity of the terms and by that sort of sophistication of thought which we have come to accept as inseparable from such discussions.

"This is a conclusion of such stupendous and far-reaching import that it may need centuries for the world to take it in and even dimly realize its implications, and where it leads us to. Sooner or later, however, it will be realized that the materialism of the nineteenth century has been nothing but an insignificant eddy in the stream of human progress. In Kant's writings his thought was evidently trammelled by the difficulty of realizing how great a leap forward he was making. Hume's scepticism had not completely done its work in his mind, for he still postulates the existence of a so-called noumenal world of things-in-themselves which are the unknowable cause of the constant newness and variety in our experience. He also retains the idea of finite individual minds, each armed, as it were, with general ideas or 'categories' which convert into the orderly system of our experience the impressions caused by the noumenal reality. His immediate successors pointed out that there was no reason left for assuming the existence of things-in-themselves outside of us. These supposed existences are nothing but the ghosts of the world of independently existing matter which Hume had shown to be non-existent. The supposed separately existing finite minds are also not proof against Hume's criticism. We must account otherwise for all the variety and 'contingency' of our universe. Both the external world of things and the spiritual world of persons have their existence, somehow or other, in only one Supreme Existence. In the efforts to show in detail how this is so the philosophical movement initiated by Kant exhausted itself for the time; but we shall have occasion to return later to these efforts.

"We must now look somewhat more closely at Kant's account of how the sensible world comes to appear to us as it does, and what bearing his conclusions, and those of his successors, have on the great biological problem which is the main subject of these lectures. Kant enumerated definitely the 'categories' or general ideas under which he believed that our perceptions are ordered. This list seems very artificial, and is based on the old formal logic, but it includes the ideas of substance, cause and effect, and reciprocal action—the idea of the physics of Kant's time. He himself, it may be remarked, was a physicist and mathematician of no mean

repute. The list limits perception to the perception of a purely physical world, such as the physical sciences described, and he had no special category for living organisms. On Kantian principles, therefore, a living organism can only be perceived as a material structure or mechanism. In this respect Kant was at one with the mechanistic school of biologists. For him, however, the reason why we must perceive organisms as mechanisms is not because they, in themselves, *are* mechanisms, but because the mind is so constituted that it can only perceive them as mechanisms.

"Kant's successor, Hegel, pointed out that his list of categories was incomplete in various directions: also that a special category or catalogue ought to be added for organic life, as the idea of life is one of fundamental ideas. There is no reason why a category or general conception of life should not be just as much constitutive of our experience as the category of substance. Here, therefore, we have a possible way out of our difficulties with the mechanistic theory of life. In trying to reduce life to physical and chemical mechanism we are perhaps in some way confusing two different categories. Kant's general philosophical conclusions have in any case thrown a quite new light on our conceptions of the physical world, and have taught us that the validity of these conceptions is of a very different nature from what was previously believed."

To me there is no more sense in this than in the ancient disquisitions on the Absolute, or the interpretation of phenomena by means of "proper" or "improper" motion, or the doctrines of phlogiston, or the conceptions of caloric, all of which contented the professors for centuries but which have left not even ashes behind; but I have no doubt that it was discourses such as I have just quoted which, rather than his good and solid work, have given to Professor J. S. Haldane the high reputation he enjoys.

How then is it possible to deal with this question in the light of true scientific conceptions?

In the first place we must endeavour to make the issue as plain as possible, just as Lavoisier sought to test the phlogiston theory by bringing the matter to a test of a critical experiment or series of experiments; and just as those who rose to that brilliant conception of heat as a mode of motion sought also for clear issues wherein the caloric theory had to justify itself, and incidentally to lay bare the meaning of 'caloric' and give evidence of such a substance. The point we have to decide is one that is nowhere touched upon either by Kant or by Hume, or discussed in the Holy Scriptures; it is simply whether in the processes of living organisms those explanations are sufficient which depend on the physical laws such as we have observed in inorganic bodies; or whether in the special circumstances of living things, we are forced to produce some new and peculiar conception, call it "Life Force" of Paracelsus, Vitalism, Biotic energy or Bildungstrieb of Blumenbach, or Élan Vital, or Necessary Genetic principle, or anything we please.

We may be invited now to observe that in regard to phenomena in the purely physical domain, the conditions of reactions vary so widely that in one case there may be forces and energies involved which are absent in another. To produce, for example, a liquefaction of certain gases, there is a

point at which, if the temperature be maintained above a critical degree, it is of no advantage to increase the pressure. Or again, in a simple example, when oxygen and hydrogen are mingled together in the vessel, we may greatly vary the conditions without producing combination unless we employ an electric spark. The more numerous and varied the substances with which we deal, so as to form reactions including them all, the more carefully must the conditions be adjusted in order to produce a required combination.

Now the living cell itself contains substances and energies immensely more complex than anything we find in our chemical retorts; and it may be, and certainly is up to the present, impossible to reproduce artificially all the conditions in their proper relation.

But reverting to the interesting image of Clerk Maxwell's demon and endowing him with a power not only of beholding the movements of the molecules, but of directing them and adjusting their proportions intelligently; then I would say that if he could take the molecules one by one and place them in the positions which, at a given moment, they occupied in a living cell, and then gave them all the movements they actually have in this cell, life would be a corollary arising out of this disposition of material; and, in the arrangement, the demon would not have required to invoke other

powers than those drawn from the various categories which we know more or less vaguely in the physical world—Movement, Heat, Electricity, Attraction, and so forth.

So far I am with the Mechanists; or, rather, I prefer to express this position for myself. Is there then nothing further? Is there nothing in Life which must be considered?

In answering this I find a point of contact with the Vitalists.

I say "Yes." Even into the mechanistic picture indicated we must introduce the conception of Life. If now be recalled what was said in the chapter on Evolution, that at every moment the organism in contact with the environment is the resultant, or rather the co-ordinated resultants of a great variety of forces, while being also at the same time the representative of a new battery of forces impinging once again on the environment, and readjusting itself in accordance with the reactions produced by this contact; then we find that the matter, although capable of explanation in terms of mechanism, is much better expressed by means of the conception of a living organism; just as the movements of the solar system which are capable of being expressed on a geocentric basis are much better represented on the helio-centric conception, so that we say, decisively, the earth and the planets revolve round the sun. The catalogue of the forces and materials

does not sum up the phenomena ; the combination of these itself produces a new factor, and this is so distinct in the case of life that we are entitled to employ in this case a special name.

This explanation is not a compromise, nor is it, I would submit, a play on words ; rather the terms Mechanism and Vitalism are of the nature of a play on words.

The Mechanists, like the eighteenth-century Materialists, rather arrogate superiority to themselves because they reduce life to their own level of conceptions ; and the Vitalists, on the other hand, plume themselves on a certain spirituality by reason of a settled resistance to facts. Science, however, once more has nothing to do with our moods and fashions ; these pass away, the laws of nature hold their force.

CHAPTER ELEVEN

THE SPIRITUAL IDEA

IN dealing with Vitalism, we have already frequently touched on the Spiritual idea, and even upon the illicit influence of such ideas. It is evidently extraordinarily difficult, even for men of science, to dissociate the wonder produced by new discoveries from that of the old orthodoxy.

M. Yves Delage told me that when he published his first results in parthenogenesis, the newspapers, as usual, took hold of the magical aspects of the matter, and this was heralded all over the world. I am not sure that he received, as Metchnikoff did, a letter from Texas from an old lady enclosing a dollar, and asking him to send a bottle; but he did get communications from Swedish girl undergraduates, quivering with a high, severe enthusiasm, burning with ideality, and thanking him in rapturous phrases for having shown them a way in which they could produce children without the "odious tyranny of the male."

And yet all that M. Delage had done was to devise mechanical means of starting development in the egg, and adapting artificial media for supplying all the conditions such as naturally obtained.

This was wonderful enough, and fraught with mystery ; as indeed, everything in our life is wonderful ; when we open an eye and receive a sensation, for example ; but the wonder was on a different plane to that imagined by the pale Scandinavian maidens.

The public has always been definitely on the side of spontaneous generation ; why, it is difficult to say, for the belief is invariably associated with a certain religious sentiment ; yet the testimony of the Scriptures is dead against that theory. Moreover, the belief has changed its character accordingly as the microscope has progressed in power. In the old days it required very little persuasion to induce people to imagine that a few pieces of cheese and a dirty rag sufficed to produce "rats and mice and such small deer" ; and the celebrated Van Helmont, who hovered between the Dark Ages and modern science, defended such beliefs stoutly. Even now there are many men of eminence in the scientific world who have a lingering belief in spontaneous generation. The most notable of the champions of this doctrine was Dr. Bastian, who carried on a great battle in favour of his thesis even against such a doughty antagonist as Huxley.

There was a certain weakness in descending from the mice to lowlier organisms, for though the problem seems to be simplified by such a step, that advantage is attained by reason of our ignorance of

the complexity of the simplest living cell. Huxley said of Bastian that he ought not to have been surprised at seeing a geranium suddenly appear under his microscope.

Tyndall believed it "unlikely that the notion of bacterial life developed from dead dust can ever again gain currency among the members of a great scientific profession." Hertwit, who considered the question settled, yet reflected with some melancholy that a considerable portion of the energy of biologists in the nineteenth century had been expended in killing this false notion. One difficulty arises from the conjectural nature of any alternative hypothesis for, again, singularly enough, most of those who reject spontaneous generation reject also the hypothesis that living organisms were directly created on this globe or found their way here from other worlds.

Even Pasteur occupied himself in the matter, though he considered that experiments on the elements found in living organisms—oxygen, nitrogen, hydrogen, carbon, sulphur, and so on—could throw no light on the problem of life. Haeckel took the opposite view, firstly on the ground of chemical synthesis of organic bodies and, secondly, from his study of one-celled organisms.

Here again the microscope did much to destroy the theory by showing that the very lowest of organisms possessed a nucleus and a complex structure,

as we have already noticed in discussing Herbert Spencer's amœba. All this did not destroy Haeckel's belief in the process, for here and ever we are brought face to face with the fact that life must have been originally produced by the synthesis of elements which exist separately as inorganic substances. At a later date Le Dantec, a French physiologist of note, vigorously maintained the same thesis.

So far we have been dealing with speculations of science, but scientific men are, as a rule, circumscribed, if not cautious individuals, and so, after all the veterans had exhausted their powers, the world was set ablaze by the discoveries of a young research-worker at the Cavendish Laboratory, Cambridge. We know now that Mr. J. Butler Burke did not really create Life in his test-tube, but simply made a pardonable error in observation. He had a bouillon of beef which he had sterilized and preserved from contact with the air. Then he subjected this to the action of radium. That little fact illustrates the manner in which the popular mind works. Radium had recently been discovered, and all the newspapers in the world were full of its wonders, and just as Schelling of old cried out:

"All is electricity! All is electricity!" so it was only necessary to utter the fatidic word "radium" to secure acceptance of the most improbable doctrines.

It is amusing to go back some twenty years and note the impression produced by Mr. Burke's discoveries not only on the lay mind, but on the scientific intellect. Lord Avebury, for instance, expressed his opinion that it was necessary to suspend judgment, his chief reason for circumspection being that, though the properties of radium were no doubt marvellous, the life-originating process ought to have taken a longer time than the impetuous Mr. Burke had given it. The great protagonist of Spontaneous Generation, Dr. Bastian, was sceptical and altogether unwilling to be swept off his feet by these new results, and he wisely observed that it required further work to show whether the bodies in question were really living things, or modified forms of crystalline matter.

Sir Oliver Lodge opined that people must not be surprised if something is done in the laboratory which may be properly considered to be of the nature of spontaneous generation. Even this was a very cautious statement for Sir Oliver, for some of his later developments have shown how much more powerful an instrument than research and logic is a spirited and unbridled imagination.

Mr. Ernest Clodd stated that the manifest intimate connection between vital and electric phenomena was all in favour of the validity of Mr. Burke's conclusions ; and in view of Huxley's opposition to Bastian, it is a little surprising at first

to find him quoting the great polemist to this effect : "It would be the height of presumption for any man to say that the conditions under which matter assumes the properties we call 'vital' may not be artificially brought together."

One of the most fervent champions of Mr. Burke was Dr. Saleeby who had himself been working on somewhat similar lines, attracted, as so many have been before and since, by the potency of radium. He said :

> "In the first place these things answer to no known form of crystals and they have none of the properties characteristic of crystals. . . . When they reach the maximum size already named, they sub-divide. This sub-division has been photographed. 'They are not merely capable of growth, but also of sub-division, possibly of reproduction, and certainly of decay.' In a word, they are alive."

Dr. Saleeby considered that it was impossible to resist the conclusion at which Mr. Burke has arrived, that he had demonstrated the evolution of living matter from lifeless matter in virtue of the action of radium.

All these opinions, even those that read somewhat strange to our eyes at present, are well within the limit of allowable error, at least in the early stages of discussion ; but the commotion created in the scientific world was a pale thing compared to the repercussion of Mr. Burke's experiments throughout the world in general. Every newspaper and every magazine of this terrestrial globe flamed with

announcements of a new era discovered and set in motion by Mr. Burke. That statement was certainly well within the mark if he had really produced life, and especially if he were able to control the production.

But the point that I wish to note particularly is the strange linking on of these new and surprising results with old beliefs which had nothing whatever to do with spontaneous generation, and which have been cited again and again for their evidence against such a production of life. Clergymen especially were vociferous in their triumphant claim that not only had Mr. Burke created life, produced a new era, but that he had also furnished at last a solid scientific foundation for various creeds which for centuries had been maintained as unerringly demonstrated without such aid, which were indeed hostile to these new experiments, and which, moreover, were mutually exclusive, one of all the others.

Meanwhile, there is something which forces one to ponder deeply when comparing the reception by the world of the important work of Mendel and the faulty observation of Mr. Burke. It was not merely the lay world, but the scientific world, which exhibited so disconcerting an inversion of values. As to the popular newspapers, when I see what extraordinary stories they erect at times on a small basis of fact, I am inclined to ask why bring in the fact at all? And it so happens that, as if in

answer to this question, I have received from the United States a wonderful example of New Thought, which seems to answer the question completely. I cannot quote it all, but a sample will be sufficient to raise our appreciation of the spiritual energy of Los Angeles, and the receptive capacity of the citizens to whom this propaganda material is principally addressed :

"All sicknesses evils and sins may thus be traced to educationary Perversions of Planes of functioning of Consciousness, and to different educationary Perversions of genetic Recapitulation-lines, represented by Intellect, Reason and Intuition, which latter perversions are *causative*. Each Organ or Thought has been aroused and cultivated in the past abnormally and unintelligently only, and the respective diseases may be recognized most clearly, *each subsequent Age adding another fundamental Disease* to which we are heir to owing to repetitive mechanistical Drill 'en masse' for the benefit of a tutored class, lacking that necessary original Re-individualization on which the evolution of the Whole depends by necessity. None of the Book-learned people can think *in terms of the Whole* of Existence. Neither towards *the benefit of the Whole* of any Nation, as history proves so abundantly. The spiritual Confusions following in the wakes of highly organized educated Terrorisms caused, increased and perpetuated aroused and evolved Evils."

Further we read :

"Life is unlimited but human Existence *here* depends on human Foresight that increases through individual and collective Life-experiences. Life and Matter are Transformations to which Education must devote itself. Each new science opens but another Wound, another Irritant on the living Map of the human Mind, to be cultivated for the common Good. Or else, it acts destructive.

"Humanity is in a State of Ferment owing to the re-melting

processes necessitated through the dissolution of the former *static* and CONCENTRIC ORGANIZED FORMATION of the social Organism. This concentric Formation is parallel to the *inner organization of Matter*. Nationalities are anti-organically organized through autocratic Rulers separating a *tutored mental Slave-class,* serving soulless Learning from the common Lot.

"We change to EPICENTRIC FORMATION of the social Organisms *parallel to the inner* ORGANIZATION OF LIFE. We change to RADIATIVE *Organization for Self-government* along vocational Lines, and change from *static* to EVOLUTIVE Education. We change from *Culture through Coercion* to CULTIVATED FREEDOM through physical, mental, spiritual and medical Freedom."

Here I can think no more ; I draw up the ladder.

CHAPTER TWELVE

SPECIALISTS AND SPECIALISM

IN the course of the present book we have observed from time to time the aberrations of scientific men when once they depart from a line of research to which they have devoted themselves.

The biologists are the worst offenders in this respect, partly because of their contact with questions of great interest on which, however, their studies touch only in a limited degree. That cannot be the entire explanation ; possibly some weight should be attached to the puzzling and tantalizing nature of their own problems and the tentative methods they generally employ in endeavouring to solve them. This produces a kind of spiritual vacuity in the soul of the biologist, and easily leads him into temptation when the promise is held of attaining any definite results. Such an argument might seem really to be of a nature to deter him from the realms of psychology or ethics, where the problems are the most elusive of all, and indeed insoluble by the methods usually employed.

The biologist, however, is unaware of these difficulties. He is like my old friend, Mr. W. T.

Stead, who was told that if he studied the Irish problem in Ireland for two years he would find himself only at the A B C of it, but that if he studied it for a fortnight, he would think he knew everything. Mr. Stead replied : "I will only stay the fortnight."

The biologists, who have succeeded in rescuing us from one of the Serbonian bogs of the Dark Ages, nevertheless found it necessary to pay a tribute to that realm by adopting some of the methods there discovered. They solve the most difficult problems of psychology by uttering the term "kinetic drive," and the result looks decidedly impressive when the kinetic drive is exhibited in a diagram in a scientific paper representing a brain where a series of arrows are drawn from portions of the cerebrum, thence to the cerebellum, thence to the organs of locomotion, in a number of decisive zigzags. I have seen even in the *British Medical Journal* a considerable space devoted to a discussion by Sir Frederick Mott on the psychological system of the German physiological-psychologist, Semon, in which the main part of the armoury consisted in terms of that sort.

Now, it is perfectly true that in the nervous activity engendered by a stimulus, resulting in a definite act, there are processes of which this so-called kinetic drive is a very gross representation, and it is also true that, preceding this kinetic drive there

is again a whole series of physiological actions which, although we do not fully understand their nature, have become so familiar to us that we neglect them in our contemplation.

Suppose, however, they have been noted for the first time. It would not be considered that we had illuminated the realm of psychology, but simply that we had indicated a preliminary series of happenings, if we affirmed that, when the eye is opened, beams of light enter, reach end organs in the retina, and so produce a stimulus which is conveyed, through the optic nerve, to the brain. The flourishing about of terms such as the "kinetic drive," the "herd instinct," or the "arc of reactions," instead of contenting us with explanations offered on that basis, should rather make us suspicious of the arguments of those who are satisfied to use them.

All the aids to psychology—biology generally, embryology, development, heredity, the anatomy and histology of the brain, clinical observations, studies of aphasia, observation of the degeneration of nerve strands with observation of mental results corresponding, experimental psychology, including if you please psycho-analysis—all these are mere adjuncts to a study which must have methods separate from those employed in any subsidiary disciplines; and the science built up by these methods must be such that it enables the psychologist also to appreciate the value of these contributory

methods, and the place they should occupy in the whole scheme of the science. I have offered a demonstration elsewhere that there is only one route by which the results can be reached, and I will leave the matter there now.

The most dangerous exercise of authority, however, is where the specialist errs in his own speciality, and that is frequent. We have already seen how Eustachius, himself a great anatomist, fought against the acceptance of the results shown by Vesalius. The experimental method was in use long before the time of Bacon ; it was employed, with admirable skill and in the true scientific manner by Gilbert, the physician of Queen Elizabeth. Nevertheless, Bacon, by virtue of his official position, created such a stir by the publication of his "Novum Organon" that his authority became almost indisputable. Bacon himself seldom employed the experimental method. When he had to elucidate any point in science he hauled down all the old books from his library and made a hotch-potch of their teaching. He held that the earth was flat, and this was only one example of the errors of his system. On the whole, except for giving a mere respectability to science, his influence was retarding.

Newton used all the weight of his authority to discredit the undulatory theory. He had been occupied during the most active years of his scientific life with problems of attraction and repulsion, and

he endeavoured to make the instrument which he had developed for this purpose apply to all the questions involving motion of material bodies.

Newton is not singular in this respect. One notices in reading the works of men of science, even in the most impersonal subjects, such as mathematics, that the style of the man is influenced by his temperament, and also by the fund of his own researches. Dipping into the midst of a dissertation, without having observed the name of the author, one would soon notice that he was reading, as the case might be, Cauchy, or Abel, or Weierstrass ; and so with Young, who was the chief exponent in this country of the undulatory theory. He saw, and no doubt rightly, undulations everywhere. When he studies the question of the tides, which Newton treated on his theory of attraction, Young introduces undulations. In both cases the outlook was too narrow ; more recent work has shown that there are other factors to be taken into account, such as, for instance, that the principal moment of inertia of the oceanic portion of the globe is referred to a different axis to that of the solid portion.

Galvani fought tooth and nail against the ideas of Volta, which have been since accepted, while Volta himself in his old age used his influence, though not with insistence, against the scientific ideas along which electricity was destined to develop.

Berzelius, the famous Swedish chemist, gave a wrong turn to scientific chemistry by false conceptions of the manner of chemical combinations, and he steadily resisted the evidence becoming more and more important that he was wrong. He also misled Faraday, and thus induced that master-experimenter to hold a doctrine which was really at variance with his own results.

The Royal Society has, at the great turning-points, been almost invariably wrong. At one time it refused to look at any paper that attempted to prove that heat was not a substance. It did not sustain the thesis of Harvey, whose reputation had suffered greatly by his demonstration of the circulation of the blood. It went out of its way to discredit the work of Edridge Green on colour-vision, and has not yet made the proper reparation. Cuvier, in France, submerged Lamarck, and secured credence especially for the weakest and most untenable parts of his own doctrine. The Academy of Science in France set itself determinedly against Darwin. The Academy of Medicine in France resisted Pasteur even with bitterness. The authority of Stahl was so great in chemistry that it induced all his confrères to accept his theory of phlogiston, even when it led to palpable absurdities.

Euler, the great mathematician, made use of his authority to support Maupertuis in his ridiculous treatment of the problem of Least Action. La-

grange rejected the most remarkable results of Fourier in mathematics; and Steiner and Plücker were at daggers drawn even to the point of deadly personal animosity.

Sir William Thomson—afterwards Lord Kelvin—put forward and defended theories in his own subject which were not conformable to the reality.

Helmholtz has several theories in different domains of physics which have since been shown to be untenable.

Kolbe used his great influence in chemistry even to the extent of refusing to van't Hoff a hearing in regard to the theory which has since been found to be true and fertile.

All the chemists were against Arrhenius when he put forward his doctrine of dis-association.

Dubois-Reymond, who was a Vitalist, acquired an enormous reputation during his lifetime, especially by his experiments in what is called animal electricity. A. Radovici has recently shown that the methods of Dubois-Reymond in this work were faulty, and that his results therefore are endued in error.

I could continue this list to a hundredfold of its present extension, with names less well-known, but I wish to refer to one or two striking instances where, in the applications of science, the authority of scientific men of great learning and repute was invoked with disastrous results.

When the steamship was invented, and even

after it had exhibited its power in fairly severe trials, the scientific authorities announced that it would never have great practical importance and they discouraged Napoleon from further interesting himself in the matter. Napoleon had also given some attention to the first rudimentary form of telegraph, but there, too, his scientific advisers persuaded him that the matter had no practical utility, and Napoleon contented himself with calling it a "Germanic idea," and proceeded to other affairs which he thought of more importance.

The development of railways in this country was also opposed by many of the scientific men. Flying machines, of course, were always scouted as merely chimerical objects ; and all these opinions, it must be remembered, were delivered in a solemn and portentous manner supported by an array of figures and mathematical symbols.

Graham Bell, the inventor of the telephone, met with considerable difficulties in the early stages of the commercial exploitation of his apparatus. He brought his invention to England in 1877 and, after a struggle lasting two years, he had got so far that he opened an Exchange in Coleman Street, London, with less than a dozen subscribers. The Post Office, to whose experts he had submitted the invention, did not regard him with favour.

Here is an official report which I quote for the sake of the regulation language employed :

"My department is in possession of full knowledge of the details of the invention, and the possible use of the telephone is very limited."

But perhaps one of the most remarkable cases of all this kind of unintelligence is found in the history of wireless telegraphy. A man of veritable genius, D. E. Hughes, had early appeared on the scene. He was originally a music teacher, and his artistic occupations had prevented him from acquiring a good grounding in the science of electricity; but his bent towards research and invention was irresistible. It is to him that we owe the microphone. He was particularly interested in the study of the effects on the electrical current of loose contacts, and most of his inventions turn upon these points. While living in Great Portland Street, London, he frequently carried some distance down the street a little apparatus containing a tube with metal filings in an electrical circuit and, having arranged for the occurrence at intervals of discharges from an induction coil, he found that he was able to obtain signals from his apparatus. This was incontestably already a case of wireless telegraphy, and Hughes himself foresaw that these experiments might be of great importance. Accordingly more than once he demonstrated them before some of the leading men of the Royal Society including Sir G. Stokes, Professor Spottiswoode and, on one occasion, Huxley. He received no

encouragement from any of them, and Stokes in particular advised him that the whole affair was little better than a toy and, moreover, that it contained nothing new because everything could be explained on the known theory of induction.

Disheartened by this verdict, Hughes did not persist in his experiments, and the matter dropped into oblivion. Many years afterwards his original apparatus was discovered, and it now figures as one of the treasures of the Natural Science Museum in South Kensington.

It is curious to note that Hertz, whose experiments prepared the way for the modern development of wireless, did not himself believe that his work was destined to be much use other than for laboratory demonstrations, still less to have the enormous commercial value we have seen.

M. Branly, who supplied the last link in the chain, which made wireless feasible, was not at the time interested in this particular application at all. He had various tubes of metal filings, and he was experimenting in order to test their resistance to the electric current, when he observed that, following an electric discharge from a Leyden jar, the resistance suddenly diminished, but that if the tube were tapped, then the resistance was restored to its original value. This coherer, as it was afterwards called, served therefore to detect the ethereal waves, and as the waves themselves could be pro-

duced at will, all the elements of wireless were complete and under control.

M. Branly once told me himself that he did have a clear notion of the possibilities of development of this system but, as he expressed it with a half-humorous sense of real values : "I could not leave my work for the sake of making money." He contented himself with giving scientific men, and the public generally, the advantage of his labours ; and as he told me, again with humorous appreciation, he found some difficulty in getting his first communication received by the Academy of Science.

Branly had expressed his results in a very simple manner and without a flourish of trumpets, but the scientific authorities had been so accustomed to find work of this sort accompanied by a great display of mathematics, and citations of authority, that they felt somewhat disappointed that they had been deprived of these adjuncts ; it was as if they had been invited to a good dinner, but found no reception ceremony, no powdered footmen, no bar of music,—simply the dinner. Men of science, you see, are, after all, only human.

So far, in dealing with influences which have been adverse to science, we have had to consider arguments arising out of the scientific domain itself ; but all this makes only half the battle. Public opinion is one of the great determining factors, but with all due respect to that potent force, even

to the extent of tacitly accepting the doctrine of *vox populi, vox Dei*, and while believing that the great heart of the people is generally sound, I have grave doubts about the value of its collective brain. Nearly every great advance in thought has had to run the gauntlet of a fiercely assailant public opinion. Public opinion is greatly formed on the basis of religion and politics ; the conception of politics is often crude, distorted, and ill-conceived, that of religion too often evaporating in sheer illusion. We laugh at the exploits of Monkeyville, in the United States, where it is a crime to teach the doctrine of evolution, but we forget how recent has been the acceptance of the doctrine in this country. One of the most influential of the London morning papers solemnly advised the electors of Southwark to vote against Professor Fawcett on the ground that he had written a favourable review of Darwin's book.

Who was the great authority on this question, really one of biological science, in Darwin's life-time ? I venture to say, and without the slightest intention of being paradoxical or of forcing the note into exaggeration, that it was Queen Victoria. The entire Court was greatly opposed to Darwin's teaching, and the champion of these ideas was the Duke of Argyll, who compensated for his limitations of vision by an exuberance of rhetorical style. But the balancing of one authority with another, Darwin's observation against the Duke's orthodoxy, was only

part of the matter. The great organs of publicity, the Press and the book world, depend on popularity, and if twenty books were offered, or a thousand articles, on this question of biology, it would only be by good fortune or again, by some special influence, that the true scientific side could be presented.

The effect of omission, it must be remembered, may be just as important, or even more important, than that of direct attack, and it is for this reason that one is tempted to doubt at times whether a complete freedom of the Press has always been beneficial to the elucidation of truth. The flood of publicity sometimes tends to darken counsel, and that even occasionally without any perversion of the facts. If, for instance, a special number of *The Times* were to give a review of the State of the Drama in London at a given time, and were to present whole columns of criticism not necessarily entirely of approval of some of the brainless plays that we see, evidently invented to catch the popular taste of the moment ; and if then at the tail-end of a page, it mentioned that a play had been staged called *Hamlet*, in which many improbable incidents occurred, wherein the author had invoked supernatural agencies, and that the hero, after having hesitated so long about killing his stepfather that he had rather wearied the patience of the audience, had finally finished in a scene which wiped off nearly all the principal players ; and if the matter

were left there without any further note, it could be hardly said that any misrepresentation had occurred; but in the whole perspective so presented, the conception of values is absurd.

That is what really occurs and what always has occurred, when a new and striking advance in science has been made; and yet, withal, possibly in perfect good faith. When to more or less inevitable misunderstandings there he added potent social influences, the situation becomes worse.

One of the stories of the march of science conveys to us the interesting little detail that Baron Thénard, a famous chemist in his day, was carrying out a scientific demonstration before the Emperor and the Empress of the French, and just before the expected moment, he bowed and said: "Now these two gases will have the honour of combining before your Imperial Majesties."

All this duly happened; Baron Thénard was eulogized and rewarded, even beyond his scientific merits, and everything that Baron Thénard uttered or published in the scientific domain was magnified a hundredfold, as compared with the serious work of much better men. That spirit, all proportions guarded, is prevalent in nearly all our own scientific Societies to-day; and indeed to such an extent as to make them less the organs for advancement of science than buttresses against new and original developments.

The matter becomes further complicated when questions of nationality enter. I once heard an educated professional man in this country say that he doubted whether the French had ever produced a really great man of science except Pasteur. He was quite in earnest in this astounding declaration, and by dint of discreet questioning I found that that was the manner in which he had been sedulously taught at the University from which he derived his degree. On the other hand, the French, no doubt over-expressing their claim, declared at one period that chemistry was a French science ; at a later period, and just before the War, the Germans made similar boasts, and they were maintained, moreover, in perfect good faith.

I once heard Dubois-Reymond declare that Theodor Schwann was the founder of three great sciences and, in bacteriology especially, the precursor of Pasteur. His words impressed me so much that I proceeded on a pious pilgrimage to the little underground, cellar-like place where Schwann, as a poor student, had carried out his simple but *durchschlagend* (cutting to bed-rock) experiments.

Now nearly all that Dubois-Reymond had said in regard to Schwann was true, and it was no doubt true also that in foreign countries insufficient credit had been given to this well-inspired scientific student. But Dubois-Reymond omitted to mention, what I discovered long afterwards, that the

Italian, Spallanzani, had anticipated Schwann in his germ theory and that, moreover, his researches and his experiments had arisen out of a lifetime of study, fertile in ideas, and systematically directed towards obtaining results of real value. Then, finally, I have had my attention called to the fact that, before Spallanzani again, Robert Boyle had been in possession of the essentials of the theory of germs, and that in a treatise published in 1546 Hieronymus Frascatoro had shown clear ideas of infection by germs. These, again, were known to the Greeks, particularly of that school which derived in continuous line from Democritus, Epicurus, and thence to the Latin poet, Lucretius.

The fact is that very few discoveries or inventions have ever been produced perfect and well-developed at first; they have grown gradually, successive additions of amendments having been contributed, perhaps, by thinkers in different countries, and very often, and perhaps justly, the science is associated with the name of one who comes fairly late in the day, but who, bringing together all the separate threads, and by dint also of original experimental work, gives to the whole science a certain completeness and importance and unassailable strength. In each country, however, the contribution which arises there, is thrown a little out of perspective and, moreover, there must be taken into account the filial piety of the disciples of the great man.

We have seen how the followers of Aristotle used his name to the great detriment of science. The students who followed Adam Smith, not a particularly romantic character, copied even his tricks of style, as faithfully as the Byronists imitated their hero ; and this devotion led rather to a cramping of the science of Economics. The students of Sir Almroth Wright, when his Opsonic Index theory was first launched forth, insisted, against all probability, that it could be relied upon within one per cent. of error, and so created a certain influence prejudicial to the acceptance of this theory and the use of the method on the Continent where, indeed, it has been now almost entirely abandoned.

The War caused a great searching of hearts in the scientific world, and one of its minor evils, if really it be minor, was that it rendered the perversion of truth patriotic and laudable. The Germans, on their part, claimed that the victory of the Hohenzollerns must be in accordance with the very Law of God, as being necessary to the culture of the world. Amongst the various replies which were hurled at them by way of literary bombs, one of the most thoughtful I noted was that of M. Dastre, a member of the Institute, an excellent man, who wrote in the style of restraint and in the endeavour to be entirely fair. He pointed out, on the one hand, how far the Germans had pursued that method which I have indicated in regard to Dubois-

Reymond, of claiming far too much for themselves. In the work of Nernst, *Treatise of Chemistry*, as Dastre points out, the name of Lavoisier, the founder of modern chemistry, is mentioned only once, while the Germans, even those of second order, are cited even to a score of times.

The main argument of M. Dastre is that the great inspirational works, that have set science moving on a new plane, are most often due to French or English thinkers, and though the Germans, with their great industry, their systematizing minds and their thoroughness, can show perhaps a larger number of workers of a secondary order, yet they miss the higher glories. This is a change from the ideas that prevailed, even in this country, before 1870, when a cult of Germanism was rife ; but as the memories of the War recede, we will probably find that the truth lies between these extremes. The Germans have not been deficient in work even that has required originality, audacity of thought, and brilliancy of conception. These qualities may be found from time to time in almost all the European countries in turn, and amid different phases of religion or of politics.

Let us then dissociate, as far as we can, our scientific criticisms from the disturbances of lesser matters, and let us be truly thankful whenever some great and illuminating work arrives that widens our vision and expands our intellectual horizon.

CHAPTER THIRTEEN

MEDICINE

MEDICINE may be the oldest of the arts, but it is the youngest of the sciences. In the year 1847 Claude Bernard said that scientific medicine did not exist, and the words might have been repeated at any time up to the year 1880.

Professor Benjamin Moore, who has studied this subject with some care, said that during the years 1875 to 1880, during which Pasteur was at last entering into the winning phase of his great battle of twenty years, the etiology of scarcely a single infectious disease had become known. A well-known textbook published in 1876 gravely affirmed that :

" Tubercle is no mere deposit but on the contrary, a living growth," and the writer proceeds to compare it with cancer. This statement in itself showed a complete incomprehension of the nature of tubercle, and a very superficial observation as to the nature of this so-called growth.

A remarkable fact, always worth noting from generation to generation, is that each successive batch of students as well as professors have been in turn satisfied with explanations of that kind.

Further, after having practised for a number of years on the basis of wrong teaching, ideas of this sort become encrusted into the medical mind; so that the practitioner, when arrived at length at the status of an authority, is prepared to assert, as of the laws of the Medes and Persians, something that is, in its turn, not easily distinguishable from something not worthy of a high degree of credence.

Just as the Schoolmen of old, and our present-day psychologists, content themselves with the invention of a phrase, so the medical men were accustomed to account for the signs of phthisis by saying that the patient had a scrofulous habit or, in the case of blood-spitting, that he had the hæmorrhagic diathesis. But again, everyone was content.

I remember once reading a very learned account of common "cold in the head," by a Dr. Richardson, who had great fame in his day as a medical man, and whose reputation was, moreover, enhanced by the fact that he was a great temperance advocate, carrying this work, excellent within certain limits, to a degree where he perverted facts in order to make his theory more telling. This discourse on cold in the head resembled, more or less, certain of those which have been already cited on evolution; that is to say, it was descriptive, with the description running somewhat superficially on what was already

fairly well-known, and devoid of any suggestion of further research ; and at length it reached its conclusion without any reference at all to what we now know to be the essential of this little malady—that is to say, the work of the microbe or microbes which produce it. But Dr. Richardson was unacquainted with the common B. Catarrhalis. And again a remarkable point is that Dr. Richardson and his auditors were entirely content with the explanation.

It is amazing at first sight to find that medical men who have had years of training in science, and are continually being brought into contact with biological laws of cause and effect, and finally led to the most impressive demonstration, as, for instance, in death, are yet content to accept explanations which, a little attention would convince them, are not explanations at all.

Recently I read an account of health conditions in Sierra Leone over a hundred years ago. The mortality explained the sinister fame of "The White Man's Grave" and the physician had taken great pains to ascertain the causes of the prevalent malaria. He attributed it to the bad air, for malaria means, etymologically, bad air. He never mentions the mosquito, and even though he called attention to a period which we know now to be that of incubation he never thought of connecting this with any sort of development. Yet he was a keen observer, except

in these essentials, and everyone was satisfied with his report.

A noted French therapeutist, Dr. Robin, of the Hospital Beaujon, to whom I send an affectionate salute across these pages, once told us that during a preceding afternoon he had been looking at some of the writings of the physicians of Louis XIV and also those of Hippocrates. He read the old Greek physician with absorbing interest and real profit, noting especially the description of an outbreak of mumps among Greek soldiers, the epidemic being so severe that many of them died. The remarks of Hippocrates showed acute observation, a scientific habit of thought, and well-judged therapeutic measures. As to the physicians of Louis XIV, Dr. Robin said they made his head swim. Yet some two thousand years had elapsed between the apparition of these two types, and this one fact is enough to make evident, what by the way we are inclined to forget, that lapse of time has not quite the same meaning as progress.

In reading textbooks of medicine one often finds the remark that a certain treatment was considered good practice at a previous time, but is now discarded. If one has the curiosity to consult the textbooks written at the earlier period, similar remarks are found in equal abundance. Medical men were continually discarding practices that had been found ineffective but, as they had never seized

the root of the matter, knowing nothing of bacteriology, they merely tried new remedies or measures which were in their turn discarded.

Certain remedies seemed to survive perennially, and of these the favourite was bleeding. Perhaps the inclination to bleed arose in the origin of modern surgery, as part of the barber's profession, and the custom was continued in the spirit of pious homage to our scientific forbears. It is not only in Parliament that "the wisdom of our fathers" is a phrase to conjure with. Untold numbers of patients must have lost their lives through this habit and, amongst them, I can cite at hazard several famous men. Washington, for instance, was simply bled to death. He was suffering from sore throat, due to an indiscreet exposure to a wintry atmosphere, but he was a strong man and even without treatment would no doubt have survived. Once he fell into the hands of the doctors it was a case of "abandon hope." Byron was also bled to death. He had contracted a fever at Missolonghi but, though he had impaired his constitution to some extent, he was still a young man with great reserves of strength. He was bled, and bled again until, finally, his powers of resistance were gone. Byron himself, with that strong common-sense which underlay his romantic temperament, doubted the advisability of the bleeding, but his doctor was inexorable. Even now one can hardly read the physician's own account without

a poignant feeling of sorrow, as he records that he bled him, but that on his next visit the patient was not better so he bled him again, and so on, with that persistence which will be found only in a man of high training and strong faith, even when the faith is ill-founded and the training altogether wrong.

Burns was another whose life was sacrificed owing to misconceptions of medical treatment though, in his case, it was not bleeding that did the mischief.

The medical profession is perhaps the most conservative of all for, in the sea of constant change, they require some solid rocks of dogma by which to hold fast when necessary. Medicine is in one sense the most philosophic of the arts, and yet the training is generally carried on with the least tincture of philosophy, and that which is imparted by way of the so-called courses of psychology, as hitherto understood, can have no other effect than to lead astray the minds which have endeavoured therein to find enlightenment.

As a matter of fact most medical men in practice are not in the least guided by such teaching, nor even by the indications of their own more tangible sciences, such as physiology.

Sir William Gowers used to say : "We do not trust our physiology enough," and he rather prided himself on being an exception in that regard. His diagnoses were often remarkably acute on that account although, in one sphere of exercise where

he had a sort of diagnostic formula, his physiology was apparently faulty. He made the cerebellum a system of controlling centres for the cerebrum, but this view has not been accepted by other neurologists. The great majority of medical men, depending neither on philosophy nor on science, follow a certain fashion, and very often follow like sheep.

In a hospital which I know, though I will not say in what city, one of the physicians discovered a hernia of the lung. Now a hernia of the lung is very rare. It is one of those things which you see in textbooks, but never in reality, or at any rate, hardly ever. The news ran round the hospital like wildfire. The doctor became famous in a day. His confrères came to examine the hernia of the lung. Distinguished surgeons appeared on the scene, all intent on seeing this wonderful production. It was decided to operate and the hospital theatre had that day a full-dress audience. At the first touch of the scalpel the hernia of the lung vanished. It was nothing but a superficial abscess.

Now some of the doctors who had examined this case were anything but fools, and they would not have been deceived originally, but they had been invited to examine the hernia of the lung, and they were either persuaded by that suggestion to find the signs or, if any of them had nascent doubts, they did not dare to express them. The kind of

moral courage required for that is the rarest endowment of educated men, and, incidentally I may say, the most dangerous to the possessor.

Suggestion not only deceives others, it is capable of deceiving the originator. I remember once as a student being invited by a great medical man to observe the accuracy of his diagnostic skill. He showed us how he had not only detected fluid in the abdomen, but how he had precisely defined its level. I was willing to believe. At that time I was willing to believe anything that a great medical man told me of his own practice, but one of the other students whispered in my ear : " Notice how Sollie,"—as he irreverently called our respected teacher—" taps harder when he comes to the level ! "

I had noticed this fact myself, but I was too diffident to give it utterance, the more especially as the case was soon to be up for operation. When that event took place, " Sollie's level " disappeared altogether and, for this excellent reason,—there was no fluid in the abdomen at all.

That was disconcerting, but professional intelligence is capable of covering up a multitude of errors. Sollie had detected the fluid on the right side but, though there was nothing wrong on this side, there was on the left side a salpyngitis " marked," to use a favourite medical slang expression, or what is a technical equivalent of slang, " marked " enough in fact to warrant surgical inter-

ference and to save the face of our physician. Everyone was happy.

On another occasion when appendicitis was the height of fashion, and when, if one was sufficiently rich and self-respecting, it seemed as necessary to have appendicitis as to have a motor-car, a patient was brought into hospital, and appendicitis was duly diagnosed. An operation was carried out, but, by one of those freaks of medicine, in which Nature sometimes seems to be indulging in a joke, every organ in the body seemed to be diseased except the appendix. Do you think the surgeon was disconcerted ? Not in the least. He wrote a learned paper on " Pseudo-appendicitis " and greatly enhanced his reputation.

The specialist is often a dangerous type because he sees his ' specialism ' everywhere, and if a man has gained a name for expertness in any particular operation, he is apt to find occasion for that operation in the most improbable cases. I knew a lady, the wife of a famous literary man, who told me a story which remains in my memory partly for the beauty of the dame and partly because of a lisp which made her telling more piquant.

She had gone to a near-specialist of my acquaintance for a slight tonsillitis which, however, he magnified ; every time he saw her he submitted her to a little treatment which she thought unnecessary and she finally summed up the situation by saying to

him : "I thuppothe, Dr. H——, if I came to you with a bwoken leg you would inthitht on blowing up my Euthtakian toob !"

Others, again, are always running after novelties, not novelties discovered in the way of an advance in science, but by hitching on old ideas to some newspaper sensation. I knew another lady who went to a noted ear-specialist, in order to obtain a cure, if possible, for chronic deafness. This expert did not blow up her Eustachian tube, but he told her that the only thing likely to help her was radium, and that for twenty guineas he would put a tube containing radium into her ear for five minutes. There was no conceivable way by which he could have helped her in this manner, and, moreover, he had no radium in the tube at all.

A ruling star in the surgical world is the Gasserian ganglion ; an operation for its removal sets the seal on the surgeon's reputation. It is a difficult operation, advisable only in very rare cases, but I have known a surgeon undertake it in spite of contra-indications.

Or again, a surgeon reads in a scientific journal of successful treatment by colopexy, and presently all the hospital is filled with colopexy, until some new fashion is ushered in. The ultra-violet rays have a great vogue at present and, in the hands of some learned physicians whom I know, satisfactory results have been obtained in many cases ; but the

fame of ultra-violet rays has become popular, and now every quack, or even half-educated qualified man, feels tempted to apply 'violet rays' even in cases where they might be harmful.

Of Freud we have already spoken, but mainly on the scientific side, slender though that side may be, but the great vogue of Freudism is due to the facility with which it lends itself to charlatanism, or to a kind of quackery that borders on, and sometimes oversteps the limit of, criminal practice. Abundant evidence has been given of this in the daily newspapers where, perhaps, a cute Yankee, unburdened by learning, but endowed with unblushing impudence and furnished with a patter of high-sounding terms, such as those which have been already quoted from Los Angeles, comes upon the scene and perverts the minds and lightens the purses of a clientèle which ranges from servant maids to dowager duchesses.

There is in the public mind an irresistible inclination towards quackery. If a man talks sense, and makes everything clear by good reason, he seems diminished by standing in the light of common day; but if he gives himself a Cagliostro-aspect, and talks inconceivable nonsense and high-sounding terms, the patient is apt to say: "What a blessed wonder!"

Charcot, who has been already mentioned, in regard to hypnotism, was sometimes carried away

by the comedian side of his character to perform extraordinary cures. On one occasion a patient of his was a young woman who, though well-formed and not unhealthy, had persuaded herself that she was paralysed. By dint of gaining her confidence, and not by the exercise of any psycho-analysis, Charcot discovered that the root of the evil was an exaggerated religious sentiment. One evening, therefore, he dressed up as St. Peter, and entered the girl's room and then, in a kindly but grave and commanding tone, bade her arise and walk. She did so and, as in the fairy-tales, lived happy ever afterwards.

Here was an excellent effect of suggestion, and as it must always be remembered that medicine is an art as well as a science, even the most serious physician should keep that means ready in his repertory of effects. The mischief is that one school in particular, the Nancy School, has bolstered up this particular aid to recovery to the exclusion of everything else. This is not only unscientific, but it is absurd.

When the late M. Coué came to this country I attended his early meetings by way of psychological study. Coué himself made great play with psychology, but, as he was an intelligent and witty fellow, I imagine that he must have carried through most of his lecture with his tongue in his cheek. One little trick of his always astonished the audience.

He would get someone on the platform to grip his hands together in a double-hook, and then ask him to will as strongly as possible not to release the hold and, at the same time, he would command him to do so. The effect was, of course, that the hook was maintained, and Coué bowed to the immense applause of the audience. The situation reminded one somewhat of Mark Twain's dilemma when he was waylaid by the bandit who, after a terrifying "Hands up!", bade him deliver his purse and then, at the slightest sign of the hands going down, roared out again: "Hands up!" Coué paraphrased this story into psychological language to his own great benefit.

He was certainly a genial and charming man, but these qualities do not account for the furore which he created. He was always surrounded by a bevy of little women who buzzed about him like a swarm of bees, palpitating with enthusiasm, frowning at any mere man who looked on indifferently, and talking that high-sounding, meaningless patter which gave them, oh once again, that blessed sense of spirituality.

On one occasion M. Coué's nose began to bleed. Here was a dilemma; it would not have been difficult to stop the bleeding by medical means, but that would have implied a want of faith in his own formula, so the little Frenchman kept muttering "It will soon stop"—"It is getting better and

better!"; and then, as one of his admirers cried in ecstasy and undiminished faith, the bleeding did stop—after five minutes. M. Coué finally died, untimely, and the gaiety of nations was diminished by his decease.

I knew a stranger case, that of a quack in Paris who attained such notoriety that the street in which he lived became blocked up by vehicles of all kinds containing his patients. This state of affairs became a nuisance, and one day the Police Commissioner called upon him and told him firmly that this business must cease.

"On what ground?" demanded the professor.

"On the ground that you are a quack practising medicine without a diploma."

The professor went to a drawer, fished out a document, and put it before the astonished eyes of the Police Commissioner. It was a medical diploma of high grade and impeccable form. The Police Commissioner could only retire, somewhat discomfited, but little by little the rumour got abroad. The patients were angry that they had been deceived, and the doctor's practice fell away more rapidly than it had sprung up.

The alienist should always be handled cautiously. Most of the doctors whom I have known whose speciality has been lunacy, have been apt to see the signs of mental aberration everywhere, and they are nearly always pessimistic in regard to results.

On the other hand, they are often very soothing and helpful to veritable lunatics. I have had friends amongst lunatics, through my acquaintance with their doctor, and I have often spent the afternoon with one, without it being distinctly called to my attention that he was a lunatic. I remember one in particular who was, though not well educated, a clever and cheerful man. He had taught himself French while in the asylum, and once he told me of a book of Dumas which he had read, where lunatics were described. "And, between ourselves," he said, "not badly!"

An exploit of his, which he enjoyed immensely himself, was to send indirectly to a Christian Young Men's Debating Society a learned paper on what he called "Spiritual Gravitation." According to his theory the two moral poles of the world were formed of "Paraffin" (evil) and "Speeritual Grahvitaation" (good). He assured me that the young men spent the whole evening discussing it, and that it had a great success. I believed him, and I had a dream for a moment that he might, except indeed for his native shrewdness, have been a great University professor.

One of the latest attractions of the medical world has been Abrams' Box.

Abrams emitted pretensions which, at the least, demanded proof before acceptance. If he had one drop of blood of a patient he could, by means of

his wonderful box and with the aid of an electro dipped into the blood, diagnose the malady and even provide a remedy. He had even brought the matter to such refinement that he could say that a cancer existed in the right breast or the left breast, as the case might be. Now considering that the blood coursed through both breasts, this claim seemed somewhat hazardous ; but it would appear that, whereas the scientific world, as well as the popular world, is often inclined to ignore a reasonable theory, it lends greedy ears to almost palpable humbug, and in that case the more audacious the claim, the higher rises the reputation of the author.

Abrams' own description of the functioning of his Box, reminded me once again of Los Angeles—not far from which neighbourhood the magic box really took birth. It must be a happy atmosphere there in Los Angeles, where even the most debilitated modes of thought acquire energy enough to conquer the world, for Abrams' oscilloclasts found a more immediate reception than the undulations of Huyghens and Fresnel.

All this is fairly commonplace, but I have read in the medical journals long criticisms, delivered in that air of complete seriousness which, although the conclusions were rather unfavourable, yet left the impression that there was a serious foundation for the work. Abrams' Box, it appeared, could give off ethereal undulations, differing according to

the malady of the patient; therefore it would not be too great a strain to deduce that complementary undulations might be employed as curative means. I almost hesitate to make the suggestion, lest the idea become realized in Los Angeles, and "oscill-etherio-therapeutic" remedies be put on the market at a couple of dollars an application.

There seems at first a certain inconsistency in the ultra-conservatism of medical men, the bitter resistance offered to Pasteur, the derision or neglect applied to Spahlinger, and the proneness to accept a new thing if it have the right aspect of marvel or the imprimatur of a man of title; but the fact is that these aberrations from the normal are due to the same cause, the lack of intellectual courage.

The man of science, as well as the man in the street, accepts the popular vogue because he is not strong enough to stand against the prevailing current; he refuses to accept something of genuine value because, again, if he did so, he would in the first case have required to possess himself of the principle by attentive study, and then to defend it intelligently when attacked. It is easier for him, and is really more advantageous to take what is called the line of least resistance.

Yet with it all I do not desire to write in any disparagement of medical science. The progress since 1880 has been extraordinary, and new fields have been opened up which send out the most

alluring invitations to bright minds, and the prospect extends in its wonder as far as we can behold. New instruments have been invented. The practical advantages that have flowed from Pasteur's researches, as for instance in bacteriology, are incalculable. Diphtheria has been robbed of its terrors. Typhoid fever even in war has been reduced to a minimum. Vaccination has helped to ward off small-pox. The use of sera has been beneficial in many diseases. Organo-therapy has at times effected marvels. The elimination of yellow fever and of malaria from infested areas has given new powers to man. Such medicaments as insulin have achieved great results. The chemist, the physiologist, the physicist have all come to the aid of medical science, and from the use of X-rays in diagnosis to the curative effects of radium, as in lupus, to the electrocardiograph, the investigation of the renal, hepatic and pancreatic functions, to various cutaneous and serological tests, taken together with indications for treatment ; all this is truly admirable. Diagnosis has become a more and sure science ; and the surgeon can also now undertake operations impossible in former days.

We have even moved a little too fast in some respects. When Dubois-Reymond described the work of Schwann, he said that one of the greatest generalizations in science was that due to the penniless little student who declared that, when any

organic change took place, the presence was necessary of a living germ.

This bold generalization does not seem to be correct as expressed in that form. It is rather true that the presence of a ferment is necessary, and that this ferment must be produced by the living germ. The remark may serve to make a bridge between the known bacterial diseases and those which do not appear to have such an origin—such as cirrhosis of the liver, pernicious anæmia, leukæmia, Graves's Disease, and a few others including, it is thought by some, cancer.

A lifetime is too short for the study of medicine. The subsidiary sciences of anatomy, physiology, chemistry, materia medica, for example, are each of enormous scope. Of these, anatomy is considered more or less of a closed book, but there are still many discoveries to be made in that domain. As to physiology and chemistry, we are only at the commencement. So much so, that mistakes are being continually made even by the most serious practitioners, in applying too directly and too crudely what are considered to be the indications of physiology. There, we must remember, that we are dealing not with substances *in vitro*, but with that illimitably complex crucible, the human body where, indeed, we know but all too insufficiently the nature of reaction of vital forces.

In these circumstances it has often seemed to

me that the ordinary medical course is in some respects too complex and too severe for most students, who really get an imperfect grasp of the science while, for those who should stand out as authorities, it is only the A B C of the business.

It might be well, therefore, to have two types of medical men. One, destined for general practice who, if he has not a complete grasp of all the underlying sciences is yet an adept at the practical manipulations and application of remedies which form the main part of medical practice, and which, in the hands of an expert, excite the wonder of the world; while, on the other hand, the expert should have a profound acquaintance with thc whole course of the underlying studies and also, what has been hitherto unattainable, clear philosophic views founded on an enlightened system of psychology.

CHAPTER FOURTEEN

ETHICS

BEING humans, we are compelled to look at everything from the human point of view, and our knowledge of the world becomes interesting to us the more intimately it impinges on our joys and sorrows and serves to guide our actions. In other words, the outcome of all our scientific knowledge is found in the sphere of ethics ; and conversely proceeding from the standpoint of ethics, we search for a clearer definition of the world by means of science, and as our knowledge of the world is gained at first hand through our senses, and is fully expressed by the combination of the presentations and ideas we thus receive ; so, finally, we reach this conclusion which many thinkers have expressed before,—that a true system of ethics should rest on a basis of psychology.

All that seems fairly clear and logical, but, as often happens in such cases, the actual practice is greatly at variance with this logic. Most of the English writers on ethics have dispensed with the psychological foundation altogether ; many of them have dispensed even with any reference to any science of value at all, and—these the most popular—

have contented themselves with the merely conventional piety, expressed in highly refined, if not somewhat affected terms ; and so there has gradually infiltrated into the popular mind that idealism or spirituality is an unhappy product of neurasthenia grafted on chlorosis. Those who are put forward as the official ethical writers—Hutcheson, Hume, Adam Smith, and the rest,—have simply caught, each in turn, at some favourite moral quality, the glories of which they have expounded in literary style. In none of these can be found anything but the most tentative effort to establish a scientific base for their work, but if a set of teachings lacks a scientific structure or, to put it in other words, a wide scope and a close relation to truth, what remains ? Simply the opinions of men of fame in their own generation ; these opinions must therefore be steeped in the atmosphere of that generation, and, to become popular, must flatter even its aberrations. Work of this kind cannot bring us very far.

Herbert Spencer certainly recognized that something quite different was necessary but, as I have already indicated, his work rested on a fundamental insufficiency which necessarily led to illusive results. Here, as elsewhere, we are led once more to the recognition of the high philosophic spirit that prevailed in ancient Greece during the brief period of efflorescence of its genius. And here once more I

render homage to the greatness of Aristotle, though even he had not found a scientific method.

What we require is something of wider and deeper view, finally presented to our minds in a certain structural scientific form capable of development in itself, and available also for application to our practical needs.

For one thing, ethics should be objective. This seems easy to say, but nothing is more remote from the popular conception. I remember that amongst the criticisms of a certain work of ethics, several of them ran on such lines as these :—"We cannot enter into the author's reasoning, but he has not made his appeal popular enough to be generally accepted."

People invariably speak as if they had a choice of Heavens in a freer spirit than they have actually a choice of tenement houses but, as I once heard a literary light exclaim, after an argument with one of his readers : "There is the only Heaven I can offer you. It is for you to take it or leave it." I am not quite sure that he did not even here exaggerate the free path of the conventional mind to which he addressed himself. We can no more accept or discard the principles of ethics than we can choose to have comets, or the law of gravitation. These are not matters for our likes or dislikes ; nor are the principles of ethics.

We should emancipate ourselves from the puerile view of sentiment, which may not even be our real

original sentiment, but something which we have taken in an imitative way from certain approved literary models.

When once, however, we raise our eyes to something true, profound as the foundation of the stars, marvellous beyond the reaches of our conception, we have a vision of something austere, perhaps too severe, but unerringly just, and linking our real world with an ideal which towers above us. Moreover, just as the law of gravitation itself, all this impinges in the most intimate way on the familiar acts of our daily lives.

A true system of ethics need not be what some philosophers, including M. Levy-Bruhl, call normative, or mandatory. There is a level at which a purely objective exposition is linked on at once to an indication of action. For instance, if we become acquainted by science with the nature of the cholera germ, and the consequences of its action in the human body, and if we find that a certain well has been contaminated with cholera, we may say, without necessity of great emphasis further than that contained in the reasons given, "Do not drink of that well." If anyone, then, whether from impenetrable ignorance or from a high conception of duty towards some special tribal god, drinks of the well, the consequences rest with himself; ethics, as a principle, in application to that particular, has already done as much as could have been required.

This illustration is only one out of ten thousand. One of the duties of a time system of ethics is to define the world in which we live, define it, that is to say, both in its visible and invisible forms, both on the physical side and the mental side, although finally the impression will become constant with us that these two worlds are intimately linked.

It might be asked then : Is Science a sufficient discipline ? I say "No," for I have known too many scientific men who were strong evidence against such an absurdity. Nothing is a sufficient discipline which does not take into account the whole scope of our activities—physical, mental and moral. Even those scientific men whose works strike us in sheer admiration, the great physicists, for instance, men of the type of Faraday or Davy, unless they be, not merely tinctured in philosophy but informed through and through in all their intellectual fibres with that spirit, are after all merely mechanicians of a higher grade. We have seen already in these pages how extraordinarily limited some of the greatest of them may be, not only in domains widely separated from their own special studies, but even in various regions of those special studies themselves.

Here again to find examples I feel induced to go back to the Ancient Greeks. They did not possess either the accurate knowledge, the great fund of learning, to which we are the heirs to-day, or even

the highly polished instruments, mechanical or mental, which have been placed within our grasp ; and, moreover, their work was often limited and faulty ; but a noble spirit was there ; a true spiritual conception, a recognition that in these things of science was something better than the feeling of gain, or even the far-reaching power that they gave us ; something that led on the mind, illuminated its darkness, and inspired us with feelings of wonder and the aspiration towards some fine ideal that bore with it the evidence of greater and higher scope of life.

This spirit seems rarer nowadays, I regret to say, though here and there its pure flame may be found undimmed. But in corporate bodies, universities, British Associations for the advancement of science, medical schools and so forth, the matter has been reduced on the one hand to terms of business ; and, on the other, there is found a recognition of all sorts of extraneous influences, social, religious and political, the spirit of caste, the sentiment of clique, which together produce inversions of value which can only be described as abominable.

To speak of Faraday again, for instance : Huxley said of him that in sheer commercial value, as reckoned by the hardest standards of cash, one Faraday was worth a millennium of kings ; but Faraday in his own time lived a great part of his life, a period when he was producing his highest scientific work,

on a salary hardly fit for the valet of a lord ; this, too, at an epoch and in a country where, in spite of what may be said, worth is estimated by social position, and social position to a considerable degree determined by money.

Then there is also the spirit of sheer perversity met with amongst philosophers who, misled perhaps by their own reasonings, or judging science from the standpoint of their own deficiencies, attempt to disparage it and to deride its methods. This spirit will be found in Berkeley, and, unfortunately in a man of great intellectual calibre who by his endowment was well fitted to have done great work in science, Dean Swift ; and also here and there in Carlyle and in Macaulay ; in Ruskin, with his weak philosophy adorned by decorative language ; and in the popular philosophy of Bergson ; and worse again, in a man of genuine scientific achievement, in regard at least to the applications of science,—Bertrand Russell.

Certainly it is true that science has often been turned to bad ends ; there is something dismal in the reflection that the War gave an immense impulsion to invention and to other applications of science, but it seems to me as foolish to inveigh against science itself on that account as to say that physical strength and health are pernicious attributes because they may aid a Bill Sikes in his nefarious work.

I return, therefore, to the point of departure of

this chapter. Science, if not sufficient, is certainly necessary to our human race in its course of upward development. Nothing in this book has been uttered disparaging to science in itself. On the contrary, whenever sharp criticisms have been offered they have been occasioned by the fact that too often we have beheld something superior in science deformed or masked by a lower aspect of false science, sometimes set up in misapprehension or ignorance, and sometimes chosen perversely and by the influence of inferior motives. But true science is always wonderful, wonderful not only in its actual and immediate discoveries, and the opening up of new visions of things which entrance us, but wonderful also in that manner in which it continually leads us onward to fresh conquests, and supremely wonderful in the forces it brings to the development of our own mental powers.

Here surely is something upon which it is worth while to stake one's life, and beholding, in this devotion, science misconstrued, blotted out, impaired by various sorts of adulteration or by the obscuring of the vision itself in the fogs of false teaching, or perversity wrought by conventional ideas, one may well feel also a fierce rage in the work of cleansing science, of salving science, so that it may stand out in its true style and proportion, in its beauty, its inspiration, its power.

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